Engaged Lifestyle and Episodic and Semantic Memory
To my parents
and to my dearest Reihaneh and Maedeh
Engaged Lifestyle and Episodic and Semantic Memory:
Longitudinal Studies from the Betula Project
Abstract


This dissertation examines whether some aspects of engaged lifestyle, marital status and leisure activity, influence memory performance in adulthood and old age. Direct effects and indirect effects, via health, are investigated. All the studies in the dissertation examine participants in the Betula project, aged 35 to 85 years. Study I investigates whether there are reliable effects of marital status on memory function in a large sample of participants in adulthood and old age. The results demonstrate that marriage has an influence on some specific types of memory functions. They show that there are significant differences between married and single individuals in episodic memory, but not in semantic memory. Also, the extent of decline in episodic memory was found to be significantly larger for singles and widowed individuals than for married people over five years. Study II examines the relationships between different types of social and cognitive activities and episodic and semantic memory. The results show that a unidirectional effect of social activity on episodic memory was detectable on all test occasions. Also, episodic memory predicted change in cognitive activity during all test waves. However, there were no significant effects with regard to semantic memory and leisure activity in either direction. Study III explores longitudinally whether engaged lifestyle, including marriage and leisure activity, directly affects memory performance, or whether the effect is mediated by health. The overall results demonstrate that marriage predicts episodic memory function directly. Leisure activity can also predict episodic memory performance ten years later, but indirectly via health. An active and engaged lifestyle can protect people against memory decline. The positive impact of engaged lifestyle on memory performance is discussed in terms of cognitive reserve theory, and in relation to the decrease in distress afforded by social support from other people.

Keywords: Engaged lifestyle, marital status, social activity, cognitive activity, episodic memory, semantic memory, health, adulthood, old age.

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List of studies

This dissertation is based on the following papers, which hereafter will be referred to in the text by their Roman numerals.


Study I has been reprinted with the kind permission of the Scandinavian Journal of Psychology.
Table of contents

I. INTRODUCTION ................................................................. 13
What is engaged lifestyle? ............................................................. 13
What is memory (declarative memory)? ................................................. 15
Episodic and semantic memory ......................................................... 15
  Memory and aging............................................................................... 17
  Memory and gender........................................................................... 17
  Memory and education....................................................................... 18
  Memory and health .......................................................................... 18
Engaged lifestyle and cognition theories ............................................... 21
  Cognitive reserve theory...................................................................... 21
  Passive models of cognitive reserve .................................................. 21
  Active models of cognitive reserve ................................................... 22
Successful aging theory ........................................................................ 23
Selective optimization with compensation .......................................... 24
Use-it-or-lose-it hypothesis .................................................................. 25
Complexity theory ................................................................................ 26
Engaged lifestyle and health ............................................................... 27
  Longevity and mortality .................................................................... 27
  Physical health .................................................................................. 27
  Cardiovascular health ....................................................................... 28
  Depression.......................................................................................... 28
Pathways linking engaged lifestyle and health .................................... 29
  Physiological and neuroendocrine pathways ...................................... 29
  Psychological pathways ...................................................................... 30
  Behavioural pathways ....................................................................... 30
Unanswered questions .......................................................................... 32
  Does marriage protect people against memory decline over time? ...... 32
  Does an engaged lifestyle improve memory function, and does good
  memory function facilitate the maintenance of an engaged lifestyle? ... 33
  Is the impact of engaged lifestyle on memory function direct or is it
  mediated by health? .......................................................................... 33
  Is there any dissociation between episodic and semantic memory in
  relation to social factors? .................................................................. 35
This dissertation ................................................................................... 36

II. METHOD ................................................................................. 37
Participants and design ....................................................................... 37
  Sample for study 1 ............................................................................ 38
  Sample for study 2 ............................................................................ 39
I. Introduction

In recent years, there has been an increasing interest in investigating the role of engaged lifestyle in cognitive function. Over the last 30 years, there have been dozens of articles and books about engaged lifestyle, including those that concern social networks and social support. It is now widely recognized that social interaction and affiliation have positive and strong effects on health. However, there are fewer studies (especially longitudinal studies) of engaged lifestyle and cognition. The main purpose of this dissertation is to investigate the role of engaged lifestyle in memory performance. My aim is to investigate the effects of an active and engaged lifestyle and its mechanisms with regard to memory performance on the basis of information in the large Betula database. In the first two studies, the effects of marital status and leisure activity on two types of memory have been investigated separately. In the third study, the role of health as a mediator between engaged lifestyle factors (marital status and leisure activity) and memory function has been examined.

What is engaged lifestyle?

The extent to which individuals’ lifestyles are ‘engaged’ is determined by their level of participation in cognitively demanding activities, social activity, and physical activity. Engaged lifestyle is a potentially important factor that can account for individual differences in physical and mental health, and also in cognition. In recent years, the positive influences of engaged lifestyle have been investigated by a variety of researchers.

There are substantial challenges to research that assess cognitively demanding activities. Most activities involve cognitive activity to some extent, and it is unclear how best to quantify this involvement (Hertzog, Kramer, Wilson, Lindenberger, 2009). In this work, only some instances of cognitive activity are selected, i.e., those where there is consensus among researchers that they should be included as forms of cognitive activity.

Social engagement has typically been defined in rather broad terms as being socially active and maintaining numerous social connections (Bassuk, Glass, & Berkman, 1999). Perhaps as a result, it has been operationalized using diverse indicators that have been combined in different ways, which complicates comparison between studies. The focus of the present studies has been on participation in activities that involve social interaction (e.g., visiting family and friends) and marital status. Various constructs have been developed to describe the social resources that emanate from a person’s integration into his or her broader social environment. But, when
Researchers consider the impacts of social relationships on health or cognition, many terms are used interchangeably. These include social network, social engagement, social tie, social support, and social integration (Berkman, Glass, Brissette, & Seeman, 2000). However, on the basis of the literature, social resources can be placed in three major research categories: (1) social networks, (2) social engagement activity, and (3) social support. Social networks encompass the matrix of social relationships to which individuals are tied (Fischer, 1982; Peek & Lin, 1999), and can include being married, living arrangement, having children, and having close social ties. Social engagement activity refers to participation in socially meaningful or productive activity (Barnes, Mendes de Leon, Wilson, Bienias, & Evans, 2004; Glass, Mendes de Leon, Marottoli, & Berkman, 1999). Social support is defined in terms of resources, and includes the informational, instrumental, and emotional support provided by other persons (Cohn & Syme, 1985). In other words, social support is defined in terms of receiving information from others that one is loved and cared for, esteemed and valued, and part of a network of communications and mutual obligations including parents, a spouse or lover, other relatives, friends, and social and community contacts (Rietschlin, 1998). Although these social constructs often overlap, each of them captures an important aspect of social interaction. Berkman and her colleagues (2000) have presented a broad conceptual model of how social networks impact on health (see Figure 1). Many terms have been defined in their model. They argue that social networks operate at the behavioural level through five primary pathways: (1) provision of social support; (2) social influence; (3) social engagement and attachment; (4) person-to-person contact; and (5) access to resources and material goods. The psychological and behavioural processes also influence health status along behavioural, psychological, and physiological pathways. However, it should be noted that the aim of this dissertation is not to determine the contribution of each social resource on memory function separately. The contributions of marital status and social activity to social networks, social support, and social engagement are considered simultaneously.

It should be noted also that, although physical activity is an important aspect of engaged lifestyle, it has not been studied in the present work.
What is memory (declarative memory)?

Episodic and semantic memory
One well-established distinction between different types of long-term memory is between declarative and non-declarative memory. Ryle (1949) distinguished between two forms of knowledge: knowing what, and knowing how. Declarative memory (knowing what) is the part of long-term memory that is concerned with the storage of factual knowledge and personal episodes, by contrast with non-declarative memory (knowing how), which is involved with the storage of physical memory of how to do something. Declarative memory can be consciously recalled, whereas non-declarative memory is unconscious (Cohen & Squire, 1980; Squire, Knowlton, & Musen, 1993). Put simply, when we brush our teeth, non-declarative memory helps us to remember how to brush our teeth, while...
declarative memory allow us to remember information, like the word ‘toothbrush’.

Tulving (1972, 1983) proposed a distinction between two types of declarative memory: episodic and semantic. Episodic memory is memory of auto-biographical events, which corresponds to the questions what, where and when about an episode (Tulving, 1993). In other words, episodic memory is about episodes or events from the personally experienced past, and it exists in subjective time and space. It requires the conscious recollection of a previous event or a study episode, and is a controlled process. Episodic memory is believed to be the memory system that developed last in evolutionary terms, and is also the last to have been developed within the individual (Tulving, 2002). Episodic memory is the only memory that, at the time of retrieval, operates backwards in time. The person has to travel back in time mentally to access the information needed. To give an example, successful retrieval of our first day at college is likely to bring to mind details about what we did and which section we were in, accompanied by the feeling that this event belongs to our personal past.

Semantic memory, on the other hand, is involved in the storage and retrieval of general knowledge, such as the meanings of words, and knowledge of facts without a specific time or place. Semantic memory does not require conscious recollection and is automatic (Tulving, 1985). For example, we know that Stockholm is the capital of Sweden, and we know that trees consist of roots, a trunk, stems, and leaves.

There is empirical support for the division of episodic and semantic memories into subtypes. Nyberg and colleagues (2003) regarded recall and recognition as subtypes of episodic memory, and knowledge and verbal fluency as subtypes of semantic memory. Functional (Gregg, 1976), brain-damage (Hirst, Johnson, Kim, Phelps, & Volpe, 1986; Hirst, Johnson, Phelps, & Volpe, 1988) and brain-imaging (Cabeza et al., 1997) studies have also demonstrated dissociation between recognition and recall. Recognition is the association of an event or physical object with one that has been previously experienced or encountered, and involves a process of comparing information with memory, e.g., recognizing a known face, answering a true/false or multiple choice question, etc. Recall involves remembering a fact, event or object that is not currently physically present (in the sense of retrieving a representation, mental image or concept), and requires the direct uncovering of information from memory, e.g., remembering the name of a recognized person, filling in a response to an open question, etc. In laboratory settings, episodic memory is typically simulated by presenting a series of stimuli or items (e.g., words or pictures) to be remembered for the purpose of a later test. In some cases, participants are
asked to recall the studied items either with or without some cue (e.g., an associate of the word presented at time of study) being presented at time of retrieval. In other cases, participants are requested to judge whether each of the items in a test list are old or new. Some of these items were studied previously (targets), and some were not (distractors). This is an example of a recognition test. Variety tasks for semantic memory have been used, including tests of general knowledge or vocabulary, lexical decision tasks, and tasks requiring the rapid reproduction of verbal materials (e.g., word fluency tests).

There is empirical research showing that episodic memory is a unique memory system with regard to some variables, such as age, gender, education and health. For the sake of simplicity, the term ‘memory’ will, from now on, be used to refer to long-term memory, specifically episodic and semantic memory.

**Memory and aging**
Most studies have shown deficits in episodic memory related to age (see Bäckman, Small, & Wahlin, 2001; Prull, Gabrieli, & Bunge, 2000). All available evidence from cross-sectional research (Figure 2) shows linearly decreasing memory performance as a function of age for episodic memory. Longitudinal studies (Figure 3), however, suggest that the age deficit may be overestimated, in that people show a relatively stable performance level up to middle age, which is then followed by a sharp decline. Studies of semantic memory show a relatively constant performance level across the adult life span (Rönnlund, Nyberg, Bäckman, & Nilsson, 2005). It can be concluded that episodic memory is unique in showing an age deficit. Collectively, the age trajectories for episodic and semantic memory differ, and underscore the need to control for cohort and retest effects in cross-sectional and longitudinal studies, respectively.

**Memory and gender**
Episodic memory is unique in the sense that it is the only memory system that shows gender differences in performance throughout the adult life span, with significantly higher performance by women (e.g., Herlitz, Airaksinen, & Nordström, 1999; Herlitz, Nilsson, & Bäckman, 1997). For example, gender differences in favour of women are found in word recognition (Hill et al., 1995), name recognition (Larrabee & Crook, 1993), recognition of concrete pictures and objects (Herlitz, Airaksinen, & Nordström, 1999), and word recall (Kramer, Delis, Kaplan, O’Donnell, & Pri-
fitera, 1997). Many studies have demonstrated that women outperform men on face recognition tasks (e.g., Lewin & Herlitz, 2002). In the literature, some explanations, in terms, for example, of the roles played by the environment and hormones, have been proposed for the gender difference in episodic memory (see Herlitz, Lovén, Thilers, & Rehnman, 2010, for further details). By contrast with episodic memory, semantic memory tasks do not show any performance difference between males and females (Herlitz et al., 1997; 1999).

Memory and education
Bäckman and Nilsson (1996) showed no age-related variation between 35 and 50 years, although there was a gradual performance decline with increasing age thereafter in tests of verbal fluency and vocabulary. In tests of general knowledge, only the two oldest cohorts showed deficits. However, when educational level was controlled for statistically, a different pattern of results emerged: middle-aged adults performed at the highest level and, with the exception of one fluency test, no age-related deficits were observed before 75 years of age. These data suggest that there may be age-related deficits in semantic memory in the general population, and education appears to be a more important factor than adult age per se in semantic memory functioning. In general, education is more connected with crystallized than fluid abilities (e.g., Kramer et al., 2004), and hence more related to semantic memory than to episodic memory (e.g., Bäckman & Nilsson, 1996).

Memory and health
Health is another important variable with regard to memory function. If health as an explanation of cognitive change is disregarded, many sources of heterogeneity among older persons are ignored; in essence, health becomes a ‘hidden variable’. As a result, the role of aging is overestimated, and important sources of variation are ignored (Spiro & Brady, 2008). Statistics on the prevalence of diseases show that, among the elderly (aged 65+), chronic diseases are commonplace, many risk factors are increased, and the taking of medication is usual. Heart disease affects about one third of the elderly; but the most serious condition, stroke, is least frequent, with a prevalence of 8% to 10% (Federal Interagency Forum on Aging-Related Statistics, 2006). Hypertension may be the most prevalent disease among the elderly, affecting 63%. However, substantial proportions (31%) of the elderly with hypertension are unaware that they have it; among those who
are aware and seek treatment, only about 20% succeed in controlling their blood pressure (Hyman & Pavlic, 2001).

Nilsson and his colleagues (1997) found that the relationships between objective (blood and urine parameters, blood pressure and pulse, sensory function, medication, and recent contacts with a physician) and subjective (self-rated) indexes of health, on the one hand, and memory function, on the other, are generally weak in all age groups. However, certain health conditions and diseases are known to affect cognitive functioning, and especially episodic memory rather than semantic memory. For example, some diseases, such as dementia, heart attack, stroke, diabetes, and hypertension, are known to affect cognitive performance (e.g., Bäckman et al., 2003; Nilsson & Söderlund, 2001; Stachran et al., 1997). In general, vascular diseases affect cognition negatively (e.g., Anstey & Christensen, 2000). The results of previous studies show that high systolic blood pressure can predict cognitive decline (e.g., Launer et al., 2000; Qui, Winblad et al., 2003). It has been suggested that hypertension is a risk factor for cognitive decline (Nilsson et al., 2004). A variety of neurophysiological characteristics of hypertension, e.g., white matter hyperintensities, and reduced cerebral blood flow and metabolism, may account for the increased risk (Waldstein, 2003). It should be noted that elderly people often suffer from more than one disease (Cauley, Dorman, & Ganguli, 1996). However, there are still only a few studies of the interaction effects of disease combinations on cognitive performance (Wahlin, 2004).

It is therefore plausible to postulate that health status might be involved in cognitive functioning. Some studies have shown that health has a stronger relationship with fluid abilities (e.g., episodic memory) than with crystallized abilities (e.g., semantic memory; see Anstey & Christensen, 2000).
and semantic memory on the basis of cross-sectional data.4 Significance was reached for both the episodic and semantic factors. The age of significant mean changes was at about age 70 for episodic memory, a decade later for semantic memory (see Figure 2). These latter patterns were derived from analyses of 1000 participants and decrements for the older participants, as described in a critical fashion in the case of episodic memory (see Figure 5). To validate the longitudinal patterns, we estimated the magnitude of memory decline for those who were 60 years or older. The magnitude of the decline was significant, and exhibit slightly less drop than episodic memory past that age, significant decline (\( \beta_{1102} \)) is in fact not reached until age 80 for episodic memory and age 85 for semantic memory. Decline is predicted past age 60 for both episodic and semantic memory (see Figure 5). Differentiation is observed for the patterns of changes for episodic and semantic memory alike. To examine the impact of education on memory changes, we compared cross-sectional and unadjusted longitudinal data. This was done on the basis of T1 data. Specifically, for the first, in line with the longitudinal data. By contrast, a significant interaction effect was attenuated as compared with the within-cohort differences in educational attainment influence cross-sectional data, we performed analyses (analyses of covariance) of the Cohort samples. The results of the Cohort analyses should be directly compared with those estimated from the cross-sectional data. ANOVAs for the independent samples confirm the nonlinear age trend. The Cohort sample (\( \beta_{1103} \)) and practice \( \beta_{1103} \) values for the episodic and semantic measures. Moreover, the point of a moderate effect size (0.5 \( \beta_{1103} \)) is in fact discernible (cf. Verhaeghen & Salthouse, 1997).

Figure 2. Estimated memory changes by age for episodic and semantic memory on the basis of cross-sectional data (Rönnlund et al., 2005).

Estimation of and Adjustment for Practice Effects

Specifically, the pattern of adjusted cumulative change scores in a critical fashion in the case of episodic memory (see Figure 5). The foregoing patterns should be directly compared with those estimated from the cross-sectional data. Further support for these trajectories was provided from the results of hierarchical regression analyses, in which the age no longer predicted performance when entered after years of education. To examine the extent to which selective attrition minimally (only about 0.2 \( \beta_{1103} \)) impacts memory, a negative age difference reverted to a positive age difference, and the impact of selective dropout on memory performance. This was done on the basis of T1 data. Specifically, for the cohort-matched sample (\( \beta_{1103} \)) and practice \( \beta_{1103} \) data, we performed analyses (analyses of covariance) of the Cohort samples. The results of the Cohort analyses should be directly compared with those estimated from the cross-sectional data. ANOVAs for the independent samples confirm the nonlinear age trend. The Cohort sample (\( \beta_{1103} \)) and practice \( \beta_{1103} \) values for the episodic and semantic measures. Moreover, the point of a moderate effect size (0.5 \( \beta_{1103} \)) is in fact discernible (cf. Verhaeghen & Salthouse, 1997).

Figure 3. Estimated memory changes by age for episodic and semantic memory on the basis of practice-adjusted longitudinal data (Rönnlund et al., 2005).
Engaged lifestyle and cognition theories

In the literature, there are several theoretical perspectives from which to explain how lifestyle activities may impact on cognitive performance in adulthood and old age.

Cognitive reserve theory

One hypothesis based on cognitive reserve theory is that there are individual differences in the ability to cope with the pathology of Alzheimer’s disease (Stern, 2002). Cognitive reserve describes an individual’s resistance to impairment in cognitive processes, such as memory, reasoning and attention, which may arise as an outcome of brain pathology caused by injury, disease or the normal aging process. The concept arose from the observation that, in a number of neurological conditions, including dementia and acute head injury, there is often no direct relationship between the extent of brain damage and the severity of the clinical symptoms that emerge (Stern, 2002). There is a possibility that a third factor modifies the relationship between pathology and clinical symptoms. A variety of terms have been used in relation to this factor, including neuronal reserve (Mortimer, Schuman, & French 1981), brain reserve (Katzman, 1993; Satz, 1993), and cognitive reserve (Stern, 2003; Whalley, Deary, Appleton, & Starr, 2004). Katzman and colleagues (1989) described 10 cases of cognitively normal elderly women who were discovered to have advanced Alzheimer’s disease pathology in their brains at death. They speculated that these women did not express the clinical features of Alzheimer’s disease because their brains were larger than average, providing them with a ‘brain reserve’. There are two broad models of reserve (Scarmeas & Stern, 2003; Stern, 2002): passive and active.

Passive models of cognitive reserve

Passive models of reserve are related to individual differences in the ‘hardware’ of brain function. In these models, increased brain reserve, such as a greater number of healthy synapses prior to pathology, leads to an increased number of remaining available synapses post pathology. If reserve is sufficient, little or no loss of function will be seen despite pathology. If, however, reserve is low, the threshold at which clinical manifestation occurs will be reached with relatively little pathology.

There is some clinical support for these models. Between 10-40% of individuals who show neurological markers of Alzheimer’s disease during autopsy have shown no cognitive impairment (Mortimer, 1997). Den Hei-
Engaged lifestyle may mediate the protection against Alzheimer’s disease or memory decline postulated in the passive model. Bigger brains tolerate greater loss before exhibiting impaired function because of a higher number of healthy synapses or neurons, which results in an increased number of the ones remaining available when a certain percentage of them are affected by a pathological process (Katzman et al., 1988). Socially and intellectually engaged lifestyle may increase synaptic density in the neocortical association cortex, which may result in a more efficient cognitive functioning of the unaffected neurons that might be capable of compensating for the loss of function of affected brain areas (Scarmeas & Stern, 2003). This issue can be addressed by means of stimulation.

Active models of cognitive reserve

Active models of reserve are related to individual differences in the ‘software’ of brain processing, and use proxy measures of brain functioning, such as intelligence test scores and measures of educational and occupational attainment. A large body of epidemiological evidence supports active models of cognitive reserve in dementia. Lower intelligence scores, and lower education and occupational attainment, are all risk factors for dementia (Katzman, 1993; Letenneur et al., 1999; Schmand et al., 1997; Snowdon et al., 1996; Stern et al., 1994). Highly educated individuals may also continue to benefit from cognitive reserve after a diagnosis of dementia, and show slower decline in at least some areas of cognition (Le Carret et al., 2005). High levels of physical, social, and intellectual activities are all protective against dementia (Kramer et al., 1999; Scarmeas & Stern, 2003).

Scarmeas and Stern (2003) proposed two possible active or ‘software’ factors that may mediate the influence of an active and engaged lifestyle (especially leisure activity) on the protection afforded against Alzheimer’s disease or memory decline. First, there is the more efficient use of the same brain networks. Even though the number of neurons or synapses might be the same, there may be enhanced synaptic activity, or more efficient circuits of synaptic connectivity, in subjects who are engaged in greater leisure activity. Second, there is the more efficient use of alternative brain networks, i.e., a greater ability to shift operations to alternative circuits. For example, a trained mathematician or somebody with a lifelong engagement in mathematics might be able to solve a mathematics problem in many
different ways, while a less experienced individual might have only one possible solution strategy available. The mathematician would have greater flexibility in relation to solving the problem if any particular solution strategy was precluded. This built-in redundancy would provide for greater resilience in the face of brain damage and the normal aging process.

**Successful aging theory**

The dictionary defines a ‘successful’ action as one that has a favourable outcome and obtaining something desired or intended. The adjective ‘successful’ has proven problematic because it has the connotation of a contest in which there are winners and losers; most gerontologists do not call someone unsuccessful merely because he or she is disabled or diagnosed with diabetes. Alternative terms used by some other researchers are aging well, healthy aging, productive aging, and effective aging (Baltes, 1994; Butler, Oberlink, & Schechter, 1990; Curb et al., 1990; LaCroix, Newton, Leveille, & Wallace, 1997; Morrow-Howell, Hinterlong, & Sherraden, 2001; Strawbridge, Wallhagen, & Cohen, 2002). Yet, successful aging has remained the umbrella term (Kahn, 2003), although there are different and important definitions of successful aging in the literature that we refer to below. It should be noted that a fundamental issue underlying the debate over how successful aging should be described has been whether it can be defined by objective criteria or is a subjective value judgment.

Rowe and Kahn (1997) defined successful aging as including three main components: (1) a low probability of disease and disease-related disability, (2) high physical and cognitive functional capacity, and (3) active engagement with life. This comprehensive definition focuses on aging as a state of complete physical, mental, and social health – not simply the absence of disease. Rowe and Kahn (1998) suggested that all three components are relative, and the relationship between them is to some extent hierarchical (see Figure 4). It is easier to maintain mental and physical function in the absence of disease and disability, which in turn allows for engagement with life. Furthermore, a high level of functioning requires both physical and mental abilities, which are independent of each other.

Each of the three components of successful aging has subcomponents. Low probability of disease refers not only to absence or presence of disease itself, but also to absence, presence, or severity of risk factors for disease. High functional level has both physical and cognitive components. Physical and cognitive capabilities are potentials for activity; they tell us what a person can do, not what he or she actually does do. Successful aging goes beyond potential; it involves activity. While active engagement with life
takes on many forms, we are most concerned with two – interpersonal relations and productive activity. Interpersonal relations involve contacts and transactions with others, exchange of information, emotional support, and direct assistance (Rowe & Kahn, 1997). In order to age successfully, a person has to go beyond potential to include activity, which incorporates engagement with life.

Depp and Jeste (2006) reviewed the literature on the proportions of subjects meeting the criteria for, and having the individual components of various definitions of, successful aging, and also correlates of these definitions. They identified 29 different definitions of successful aging in 28 published articles. The mean reported proportion of successful agers was 35.8% (standard deviation: 19.8). Multiple components of these definitions were identified, although 26 of the 29 included disability/physical functioning. The most frequent significant correlates of the various definitions of successful aging were age (young-old), non-smoking, and absence of disability, arthritis, and diabetes. Moderate support was found for greater physical activity, more social contacts, better self-rated health, absence of depression and cognitive impairment, and fewer medical conditions.

Selective optimization with compensation
An alternative model, put forward by Baltes and Baltes (1990), is that of ‘selective optimization with compensation’. This model recognizes that an

Figure 4. Rowe and Kahn’s model of successful aging (Rowe & Kahn, 1997). Reprinted with the permission of Oxford University Press.
individual’s experience of aging is subjective and unique, and that individuals can remain mentally strong while physically frail, and can adapt to the limitations they experience as a result of aging. For example, individuals can prioritize things important to them and use strengths in one domain, and also coping strategies, to compensate for weaknesses in others. A good illustration of this is the use of lists to compensate for deficits in short-term memory. On the basis of this definition, successful aging is defined as doing the best with what one has (Baltes & Carstensen, 1996).

In contrast to comprehensive models of successful aging, several studies have used self-report measures to identify individuals who are aging successfully. In one study (Strawbridge, Wallhagen, & Cohen, 2002), participants were asked simply how strongly they agreed or disagreed with the statement ‘I am aging successfully (or aging well)?’ Interestingly, 50.3% of older individuals identified themselves as aging successfully. Montross and colleagues (2006) asked participants to report their self-perceptions of successful aging on a 10-point scale (1 = least successful, 10 = most successful). In total, 92% of participants identified themselves as successful agers. Similarly, in another study (Tate, Lah, & Cuddy, 2003) participants were asked ‘Would you say you have aged successfully?’ About 84% of participants responded positively to this question.

The use-it-or-lose-it hypothesis
The ‘use-it-or-lose-it’ hypothesis of cognitive aging predicts that engagement in cognitive, social, and physical activities in late adulthood prevents the deterioration of cognitive abilities by ‘exercising’ them through their applications in various environments (Salthouse, 1991). It is predicted that individuals who participate in many activities perform better on cognitive tests, experience less cognitive decline over time, and possibly even have a reduced likelihood of developing neurodegenerative disorders (e.g., Alzheimer’s disease, AD) compared with inactive individuals (see Fratiglioni, Paillard-Borg, & Winblad, 2004; Small, Hughes, Hultsch, & Dixon, 2007 for reviews). However, there is support for a relationship in the opposite direction, where changes in cognitive performance result in changes in activity engagement. In other words, individuals who have experienced cognitive decline may withdraw from activity engagement because they find the same activities more difficult, and instead a cause of frustration and a reminder of their lost abilities. On the other hand, individuals with high levels of cognitive ability have a greater capacity to engage in activities successfully, and consequently become more motivated to participate in future activities (see Bielak, 2010). This debate can be summarized by
separating ‘differential preservation’ from ‘preserved differentiation’ (Salthouse, 2006). The differential preservation hypothesis is consistent with the use-it-or-lose-it hypothesis in that it views variations in cognitive performance with increasing age as due to differences in activity levels, whereas preserved differentiation suggests that active individuals are likely always to have had higher levels of cognitive performance (Salthouse, 2006). Accordingly, although there is support for both hypotheses in the literature, neither can yet be regarded as conclusively confirmed.

Complexity theory
Schooler and colleagues (e.g., 1999) have argued that the substantive complexity of environments, defined in part in terms of ill-defined contingencies and substantive latitude in decision-making, may reward cognitive effort. Furthermore, they contend that exposure to complexity may generalize to other situations, including performance on cognitive ability tests. By contrast, exposure to relatively simple environments may contribute to decrements in intellectual functioning. It has been demonstrated that substantive complexity in work environments (Schooler, 1999) and during leisure time (Schooler & Mulatu, 2001) is related to superior cognitive functioning, even after controlling for potentially confounding variables.

More generally, the results of the Kohn-Schooler (1978) occupational studies and their extensions are consistent with a large body of research from a wide range of disciplines, including animal-based neurobiology studies (e.g., Greenough, Cohen, & Juraska, 1999; Kempermann, Kuhn, & Gage, 1997), which strongly suggest that exposure to complex environments increases intellectual functioning throughout the life course and across species. On the basis of this evidence, Schooler (1984, 1990) developed a rough-hewn theory of the psychological mechanisms underlying such effects. According to this theory, the more diverse the stimuli, the greater the number of decisions required, the greater the number of considerations to be taken into account in making these decisions, and the more ill-defined and apparently contradictory the contingencies, the more complex will be the environment. To the extent that complex environments reward cognitive effort, individuals should be motivated to develop their intellectual capacities and to generalize their applications to other situations. Conversely, continued exposure to relatively simple environments may result in a decrement in intellectual functioning, in keeping with the low level of environmental demand.
Engaged lifestyle and health

The health benefits of engaged lifestyle have been consistently confirmed over the years (e.g., Wyke & Ford, 1992). The relationship between engaged lifestyle and different aspects of health, including longevity, physical health, cardiovascular health, and depression, are described in what follows. The three pathways that have been proposed as links between engaged lifestyle and health are also considered.

Longevity and mortality

The association between social integration, including social networks, social support, and social activities, and mortality has been extensively investigated. Over the years, there have been numerous studies reporting increased longevity from social networking, social engagement, and social support (for a review, see Seeman & Crimmins, 2001).

Some studies have suggested that the social ties, social networks, and/or social support that marriage often provides may reduce the risk of mortality (e.g., Eng, Rimm, Fitzmaurice, & Kawachi, 2002). The greater longevity of married, as compared with unmarried, people has been repeatedly demonstrated in previous studies. A rather large number of investigations have shown higher mortality among single, divorced and widowed people, both males and females (Joung, Glerum, Poppel, Kardaun, & Mackenbach, 1996; Kaplan & Kronick, 2006; Nakanishi et al., 1998; Orlie, Backlund, & Keller, 1995; Sundquist & Johansson, 1997; Tucker, Friedman, Wingard, & Schwartz, 1996). In general, married people enjoy better health, make fewer demands on the health care system, and live longer than unmarried people (e.g., Kisker, 1990).

Leisure activities have also been examined in relation to longevity. Some studies have demonstrated that productive and volunteer activities lower the risk of mortality (e.g., Glass, deLeon, Marottoli, & Berkman, 1999; Luoh & Herzog, 2002). Cultural and solitary activities can also have survival benefits. Cultural activities, such as going to the cinema, theatre or exhibitions, decrease mortality risk (Konlaan, Bygren, & Johansson, 2000), as too do solitary activities, such as hobby pursuits and gardening (Jacobs, Hammerman, Cohen, & Stessman, 2008; Lennartsson & Sliverstein, 2001).

Physical health

Researchers report that married people have better mental and physical health than non-married people. Married individuals have better health

A vast body of research has investigated the associations between different kinds of leisure activities and physical health. The research shows not only that physical activity protect individuals against functional decline and disability, but also that other kinds of leisure activities have a positive influence. Menec (2003) found that volunteer activities helped to sustain the activities of daily living (ADL) six years later on. In another study (Louh & Herzog, 2002), it has been shown that volunteer activities and paid work after retirement protect against constraints on ADL two years later on.

**Cardiovascular health**

The impacts of engaged lifestyle on coronary heart disease (CHD) and stroke have been investigated in previous studies (Marrugat, Sala, Masiá, 1998; Rosengren, Lars Wilhelmsen, Orth-Gomér, 2004). There is strong evidence of an independent aetiological and prognostic role of social support in CHD (Hemingway, Marmot, 1999). Previous studies have shown that a higher level of social integration decreases the risks of CHD and stroke (Orth-Gomer, Rosengren, & Wilhelsen, 1993; Kawachi et al., 1996). Social integration and social support also seem to have positive effects on the recovery process after myocardial infarction and stroke (Seeman, 1996).

**Depression**

Another health outcome that has been related to engaged lifestyle is a lower level of depressive symptoms and depression. Most studies report that gaining a spouse improves mental health, and that loss of a spouse negatively affects mental health (Hope, Rodgers, & Power, 1999; Horwitz, White, & Howell-White, 1996; Kim & McKenry, 2002; Lamb, Lee, & DeMaris, 2003; Marks & Lambert, 1998; Simon, 2002; Simon & Marcussen, 1999; Williams, 2003).

Some studies show that people who marry for the first time report significantly less depression than those who remain single (Lamb et al., 2003; Marks & Lambert, 1998; Simon, 2002). Loss of a marital partner is clearly
associated with a decline in mental health (Simon & Marcussen, 1999; Williams, 2003).

Many studies have also reported protection against depression for more socially engaged individuals (see Seeman, 1996, for a review). In one study, Glass and his colleagues (2006) showed a positive association between social engagement, including social and productive activities, and a low level of depressive symptoms.

**Pathways linking engaged lifestyle and health**

Several pathways linking engaged lifestyle and health have been suggested. In general, engaged lifestyle provides individuals with added mental stimulation, which often contains contact with other people. Three kinds of pathways – physiological, psychological, and behavioural – partly overlapping and often at work simultaneously, link engaged lifestyle to health. The three kinds of pathways are described below.

**Physiological and neuroendocrine pathways**

Engaged lifestyle can reduce physiological and neuroendocrine responses to stress under a broad array of conditions. Studies suggest that engaged lifestyle, including social support, has beneficial effects on the cardiovascular, neuroendocrine, and immune systems (Seeman & McEwen, 1996; Uchino, Cacioppo, & Kiecolt-Glaser, 1996). For example, Linden and his colleagues (1993) found that the perception of social support is correlated with lower systolic blood pressure in working women, indicating that the presence of, or the perception of, social support may enable women to go through a stressful workday without experiencing as much sympathetic arousal as women who feel they lack support. In fact, simply knowing that social support is potentially available leads to reduced cardiovascular reactivity in response to stress, even if that social support is not actually activated (Uchino & Garvey, 1997).

Social support also affects endocrine functioning in response to stress. One study of older people found that the quantity and quality of social relationships are related to levels of urinary norepinephrine, epinephrine, and cortisol (Seeman, Berkman, Blazer, & Rowe, 1994). Other studies have found that social support is associated with reduced cortisol responses to stress, which can have beneficial effects on a broad array of diseases, including heart disease and cancer (Turner-Cobb, Sephton, Koopman, Blake-Mortimer, & Spiegel, 2000). Generally speaking, social support is
associated with better immune functioning among support recipients (Herbert & Cohen, 1993).

**Psychological pathways**

Psychological pathways, such as relaxation and stress reduction, may also be commonplace. Active individuals, with more frequent contacts and greater integration, have more opportunities to engage with others, which results in positive emotional states, such as social competence, self-esteem, self-efficacy, and adequate mood, all of which lead to lower stress.

It has been shown that some activities, such as productive and volunteer activities, provide individuals with feelings of usefulness and competence as well as a sense of control and mastery (Berkman et al., 2000). Participation in most non-solitary leisure activities results in an enlargement of the individual’s social network. As well as establishing different kinds of support, such as informational, instrumental, and emotional support, individuals in social networks may encourage healthy behaviours by being exercise partners, sharing meals, or aiding smoking cessation. It should be noted that social support also has a positive influence on the provider. For example, Krause and Shaw (2000) found that older persons providing emotional support seem to enjoy better self-esteem.

Berkman and colleagues (2000) argue that the benefits of social integration are not restricted to the establishment of support, but possibly depend more on the individual’s participation in a meaningful context. Maier and Klumb (2005) have shown that being in a context with friends decreases mortality risk above and beyond the effect of activity alone.

**Behavioural pathways**

Behavioural pathways are closely related to physiological ones. Engaged lifestyle is likely to affect social networks and access to social support, which in turn affect health-related behaviours (Berkman et al., 2000).

In explaining the association between marital status and health, two hypotheses have been presented: ‘protection’ and ‘selection’. According to the marriage selection hypothesis, healthy people are more likely to get married than those who are unhealthy and, if the latter do marry, they are less likely to maintain their marriage. According to the marriage protection hypothesis, marriage provides a shield against behaviours that present a health risk (smoking, drinking, unhealthy diet, promiscuous sex, etc.), as well as offering a supportive relationship and personal financial benefits. It has been postulated that marriage serves as a source of health promotion.
by somehow encouraging positive health behaviours, which over time culminate in and facilitate desirable health outcomes, and even longevity (Kiecolt-Glaser & Newton, 2001). For example, it has been shown that married people have a lower rate of smoking (Cox, Feng, Canar, & Ford, 2005).

Most evidence has tended to point to the protective effects of marriage on health and the stressful experiences that accompany divorce, separation, or widowhood (Ross, Mirowsky, & Goldsteen, 1990). Marriage is beneficial in several ways. It provides ‘protection’ to individuals by providing a relatively stable and caring family environment (Goldman, 1993). Being married not only enhances marriage partners’ coping strategies in dealing with stressful life events and health concerns, but also makes the partners more likely to engage in healthy behaviours (Kiecolt-Glaser & Newton, 2001). Perhaps more importantly, being married also reduces the level of isolation from important social networks, establishes economic ties, and offers emotional and instrumental support (Mastekaasa, 1994).

Participation in activities also gives access to a wider social network. A socially supportive network can provide relevant information and assistance on health care and health practices, and therefore influence behaviours related to health-care utilization and compliance with medical regimens. Other health behaviours are also regulated by the individual’s social environment because of the influences exerted by the social network (Berkman et al., 2000). Such influences may affect norms (both negatively and positively, although the positive may be relevant at older ages, and the negative at younger ages) regarding physical activity, diet, sleeping habits, smoking and excessive alcohol consumption, behaviours that in turn have physiological consequences (Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002).
Unanswered questions

It has been established that cognitive performance has different determinants, including genetic disposition, educational attainment, gender, different types of activity, and so on. In recent years, engaged lifestyle has increasingly been considered as a factor that may protect people from physical and mental diseases. According to the Swedish National Institute of Public Health, there are four cornerstones to aging well: good eating habits, physical activity, social interaction/support, and engagement in meaningful activities (Swedish National Institute of Public Health, 2007). Three out of the four are related to engaged lifestyle, which is of particular importance in adulthood and old age. It has been suggested that changes in everyday experiences and leisure activities may cause disuse, and the consequent atrophy of cognitive processes and skills (Salthouse, 1991). The ideas of ‘use-it-or-lose-it’ or ‘disuse’ have been frequently tested in the context of cognitive aging (see Small, Hughes, Hultsch, & Dixon, 2007). Taking into account the considerable plasticity of the cognitive abilities of older adults, it might be expected that engagement in some activities would at least give rise to stable performance, and may even reverse age-related changes. Although some of the identified risk factors for a faster rate of cognitive decline are fixed or not readily modifiable (e.g., genotype; Anstey & Christensen, 2000), individuals can potentially alter their level of engagement in cognitive, social, and physical activities, all of which can stimulate the cognitive system. However, our understanding of the nature of the indicators of engaged lifestyle is still limited. Several questions need to be considered, as described below.

Does marriage protect people against memory decline over time?

Regarding marriage as one possible indicator of engaged lifestyle, there are questions that need to be examined in greater detail. Is there any specific effect of marriage on cognitive function (especially memory function)? Is there any differentiation between types of unmarried groups regarding cognitive function? In most previous studies, the Mini Mental State Examination (MMSE) test, a general cognitive ability test, has been used in this area (Van Gelder et al., 2006; Håkansson et al., 2009), but different types of memory tasks have not yet been investigated. To our knowledge, no research has yet considered the impacts of marriage and age on memory tasks simultaneously, or longitudinally. Some previous studies (e.g., Van Gelder et al., 2006) have also compared married and non-married individuals in general, but people of different non-married status, namely the single, divorced and widowed, have not been investigated separately. In
sum, there is a need to study whether the established positive relationship between marriage and health is also observable in relation to marriage and various aspects of memory, more specifically episodic and semantic memory.

**Does an engaged lifestyle improve memory function, and does good memory function facilitate the maintenance of an engaged lifestyle?**

There has been no general agreement in the literature over the influences of different activities on cognitive functions. Although some studies (e.g., Lövdén et al., 2005; Ghisletta et al., 2006; Newson & Kemps, 2005), in line with the use-it-or-lose-it hypothesis, have found an influence of activity on cognitive functioning, other researchers (e.g., Aartsen et al., 2002; Salthouse, Berish, & Miles, 2002) have found no such influence or found an influence in the opposite direction, of cognitive performance on activity, in line with the preserved differentiation hypothesis. There is also the question of different types of cognitive tasks. In two studies (Ghisletta et al., 2006; Newson & Kemps, 2005), an influence of activity on verbal fluency tasks was not found, but influences were detected on other types of cognitive tasks (perceptual speed, picture naming, and incidental recall). Another question relates to types of activities. Whereas some studies have considered general leisure activity (e.g., Mackinnon et al., 2003; Newson & Kemps, 2005), others (e.g., Aartsen et al., 2002) have focused on some specific types of activities. Social and cognitive activities are two important types of activities, which have been shown to have different influences on cognitive performance (e.g., Niti et al., 2008). Accordingly, there is a need to consider the following questions: Does the stimulation provided by typical everyday activities facilitate the maintenance and improvement of general cognitive skills (see Hultsch, Hertzog, Small, & Dixon, 1999)? Does high cognitive performance facilitate the maintenance of an engaged and active lifestyle? Is there evidence supporting bi-causality? Is there any differentiation between cognitive tasks as well as between types of leisure activities? It is necessary to study the disparities between earlier studies with regard to the differentiated influences of social and cognitive activities by using more specific memory tasks.

**Is the impact of engaged lifestyle on memory function direct or is it mediated by health?**

The positive relationship between engaged lifestyle and health is one of the few true relationships universally found in previous studies. Numerous
studies have shown that married individuals enjoy better physical and mental health than those who have never married, or are widowed or divorced (e.g., Schoenborn, 2004). Married individuals are less depressed than non-married individuals (e.g., Johnson, 2002; Meadows, McLanhan, & Brooks-Gunn, 2008). Married men and women also experience greater longevity than those who remain unmarried or lose their partners (Manzoli, Villari, Pirone, & Boccia, 2007). Also, some studies have suggested that engaging in different types of activity has benefits for physical and psychological health. The health benefits of activities, especially physical activities, are substantial in terms of the cardiorespiratory system, reduction in or control of hypertension, improved tolerance of stress, and reduction in poor health habits, including cigarette smoking, alcohol consumption, and poor diet (Taylor, 2006). Previous studies have demonstrated that people who regularly attend cultural events have a lower level of mortality (Bygren, Knlaan, & Johansson, 1996). Cognitive, physical, and social activities have beneficial influences on psychological states, such as mood, anxiety, depression, and tension (e.g., Wada et al., 2004).

It has also been established that engaged lifestyle and cognition are related, and that the risk of cognitive impairment or cognitive decline is greater for unmarried than for married people (Håkansson et al., 2009; Van Gelder et al., 2006). It has also been shown many times that there is a link between level of participation in activities and performance on various cognitive tasks, both in longitudinal studies (Ghisletta et al., 2006; Lövdén et al., 2005; Mackinnon et al., 2003; Newson & Kemps, 2005) and in cross-sectional studies (e.g., Luszcz, Bryan, & Kent, 1997). And, Fratiglioni and colleagues (2000) showed that an extensive social network protects against dementia. Individuals living alone and those without any close social ties run a greater risk of developing dementia than individuals who live with others or have close social ties (Van Gelder et al., 2006).

On the other hand, previous studies have demonstrated the role played by health in cognitive functioning. For example, people who have diseases such as hypertension, heart disease, diabetes, and stroke (e.g., Bäckman et al., 2003; Nilsson & Söderlund, 2001; Nilsson & Wahlin, 2009) show poorer cognitive functioning. Although in previous studies the mediating role of health in the relation between age and cognitive function has been examined, there is no research, to our knowledge, on the possible mediating role of health in the relation between engaged lifestyle and memory function. We expected that health would be an important mediator in relation to memory performance in this case.
Is there any dissociation between episodic and semantic memory in relation to social factors?

According to Tulving (1972), there are two advanced memory systems: the episodic and the semantic. It has been repeatedly shown that episodic memory is the more sensitive memory system of the two concerning some variables, such as age (e.g., Rönnlund, Nyberg, Bäckman, & Nilsson, 2005), gender (e.g., Herlitz et al., 1997), and health (e.g., Bäckman et al., 2003). Based on these findings, we expected that the effects of engaged lifestyle on memory would be more pronounced in episodic memory than in semantic memory. As mentioned above, whereas episodic memory is about remembering episodes or events from the personally experienced past, and exists in subjective time and space, semantic memory is about general knowledge without a specific time or place (Tulving, 2002). Accordingly, it is interesting to study the dissociative effects between episodic and semantic memory on the basis of engaged lifestyle. Since engaged lifestyle is related to a life event and everyday memory, it would be expected to see the effect of marital status and leisure activity more on episodic memory than semantic memory.
This dissertation

The main aims of this dissertation are to see whether engaged lifestyle, in terms of marital status and leisure activity, impact on memory performance, and to achieve a better understanding of how engaged lifestyle may affect memory function over time. On the basis of the previous studies and models in the literature, we developed a conceptual model of the relationships between engaged lifestyle, health, and memory performance. As can be seen in Figure 5, marriage and leisure activity were expected to influence memory function via health. Study I examines whether there are reliable effects of marital status on memory function in a large sample of individuals in adulthood and old age. Study II examines the relationship between different types of activities, both cognitive and social, on episodic and semantic memory. Study III explores whether the effects of marriage and leisure activity on memory performance are direct or whether they are mediated by health. In addition, we also test whether the effects are different for the two types of memory: episodic and semantic. The following research questions were posed, all with a focus on middle and old age:

1. Does marriage (married individuals compared with single, divorced and widowed individuals) have any effect on memory performance (episodic memory compared with semantic memory)? This question is addressed in the first study.

2. Do different types of leisure activities (social activity compared with cognitive activity) have any effect on memory function (episodic memory compared with semantic memory)? This question is addressed in the second study.

3. Does subjective health act as a mediator in the relationship between engaged lifestyle and memory performance? This question is addressed in the third study.

![Figure 5. The conceptual framework guiding the current research.](image-url)
II. Method

Participants and design

Data from the Betula project were used for all three studies. The Betula project (Nilsson et al., 2004; Nilsson et al., 1997) is a longitudinal, population-based multi-cohort study. The general aim of the project is to explore memory functions and health across the life span, and there are few studies of the relation between adult age and memory. To obtain a better description of the relations between age, memory and health, population-based samples of healthy adults at ages 35-80 years participated in the project. As well as studying the development of memory and health in general, a more specific purpose of the Betula project is to explore early, preclinical signs of and potential risk factors for dementia. In the Betula project, participants give information about their habits and experiences, e.g., leisure activities, critical life events, marital status, and accommodation status. During the period of the longitudinal study, some of the participants developed dementia and, for these individuals, early preclinical signs and possible risk factors for dementia have been examined.

Participants were randomly sampled from the population of Umeå, which is a city in northern Sweden of about 100 000 inhabitants. Participants were selected from 10 different cohorts at the ages of 35, 40, 45, 50, 55, 60, 65, 70, 75, and 80 years. The gender distribution in each cohort was chosen to reflect the actual gender proportions at corresponding ages in the Swedish population. The Betula project has a narrow age cohort (NAC) design. Five waves including 6 samples have been administered so far. There were three samples of 1000 participants, each of which contained 10 cohorts with 100 participants in each cohort.

During the first wave of data collection (T1: 1998-1990), the first sample (S1) was tested. Five years after the first occasion of measurement, S1 was tested for a second time (T2: 1993-1995). At the second wave, two new samples, sample 2 and sample 3 were selected for initial testing. The participants in S2 were then of the same ages as those in S1 at T2, and those in S3 were of the same ages as those in S1 at T1. After another five years, all participants were tested again (1998-2000), and a fourth sample was taken (S4). The number of participants in S4 was 600. Participants in S1 and S3 were tested again five years later (2003-2005), and a fifth sample (S5) was taken. The number of participants in S5 was 600. All participants in S1 and S3 were tested in the fifth wave (2008-2010), as were 350...
participants in a new sample (S6). The waves and samples in the Betula project are shown in Table 1.

Table 1. Waves and samples in the Betula project.

<table>
<thead>
<tr>
<th>Wave</th>
<th>Sample</th>
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<tbody>
<tr>
<td>T1 (1988-1990)</td>
<td>S1</td>
</tr>
<tr>
<td>T2 (1993-1995)</td>
<td>S1</td>
</tr>
<tr>
<td>T3 (1998-2000)</td>
<td>S1</td>
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<tr>
<td>T4 (2003-2005)</td>
<td>S1</td>
</tr>
<tr>
<td>T5 (2008-2010)</td>
<td>S1</td>
</tr>
</tbody>
</table>

Sample for study 1

A total 830 males and 1026 females participated in the study. Three samples of participants in the Betula Study were selected for this study: S1, S2, and S3. Participants in each sample belonged to ten different age cohorts, ranging from the age of 35 to the age of 80 for S1T1 and S2T2 (i.e., ages 35, 40, 45, 50, 55, 60, 65, 70, 75, and 80), and from the age of 40 to the age of 85 for S3T2. S1T1 (1,000 participants), S2T2 (997 participants), and S3T2 (966 participants) had approximately 100 participants in each age cohort. The data reported here come from the first and second waves of data collection for each sample. The participants in S1 were tested for the first time between 1988 and 1990 (Wave 1, or W1), and for the second time between 1993 and 1995 (Wave 2, or W2); the participants in S2 and S3 were tested for the first time between 1993 and 1995 (W1), and for the second time between 1998 and 2000 (W2). In order to minimize the effect of disease on cognitive function, we excluded participants who had been diagnosed as having dementia up to 2005 (n = 210), and also participants who had had a stroke (n = 69).

Since duration of marital status was a critical factor in our longitudinal study, we selected participants who were identical in marital status between W1 and W2; that is, they had been married/living together, single, divorced or widowed for at least five years. It should also be noted that the participants with non-identical marital status (i.e., married-divorced, mar-
ried-widowed, single-married, divorced-married, and widowed-married) between the two waves were insufficient in number to be analysed separately, and we excluded them from the analyses.

The overall return rates between waves of data collection were highly stable across the samples. For S1, 87% returned during W2; for S2, 85%; and for S3, 86%. The reasons for failure to return during W2 were generally very similar across the samples: death (about 7%), moving away from Umeå City, the venue of the study (about 4%), and refusal (about 4%). The reasons for dropout were reasonably consistent across the married, single, divorced, and widowed categories, although there was a somewhat higher death rate in the widowed group.

The participants were grouped into two age cohorts, 35-60 and 65-85, and studied at intervals of 5 years. Episodic memory tasks concerned recognition and recall, and semantic memory tasks knowledge and fluency.

Sample for study 2
A total of 794 old people (751 males and 903 females) were selected for this study. Two samples of participants in the Betula Study were chosen: S1 and S3. The participants belonged to five different age cohorts, ranging from the age of 65 to the age of 85 (i.e., ages 65, 70, 75, 80, and 85). The recruited participants were tested during T2 (1993-1995), T3 (1998-2000), and T4 (2003-2005). We excluded participants from the study if they had been diagnosed with dementia (n = 172) or stroke (n = 3) up to 2005. The participants were studied on three occasions over a period of ten years.

Sample for study 3
For this study, participants were taken from two samples in the Betula project: S1 and S3. The age range of participants was from 40 to 90 years old, and 10 age cohorts (i.e., 40, 45, 50, 55, 60, 65, 70, 75, 80, and 85) were included. For this study, data on three occasions, T2 (1993-1995), T3 (1998-2000), and T4 (2003-2005), were selected for the analyses. Participants who had been diagnosed with dementia or stroke up to 2005 were excluded from the study. Since we were going to study the roles of marital status, leisure activity and health on memory performance longitudinally, each of these variables was measured on different occasions. All covariates, including marital status and leisure activity, were measured during T1. Specifically, people who had identical marital status during the 5 years from T1 to T2 were selected for this study (married-married, single-single, and widowed-widowed). Participants with non-identical marital status
were excluded from the sample. Since we wanted to have a dummy variable for marital status, married participants were considered as a first group, and single and widowed participants as a second group. Previous research has demonstrated that the rate of memory decline is higher in the single and widowed groups, but not in the divorced group (Mousavi-Nasab et al., 2012). We therefore excluded the divorced group from our study. The data for health and memory performance came from T2 and T3, respectively. Thus, we could examine longitudinally whether marital status and leisure activity – two important aspects of engaged lifestyle – can predict memory performance directly, and also indirectly via health.

**Measures**

**Episodic memory tests: Recall**

**Free recall of actions.** Participants were presented with two lists of 16 verb–noun sentences, each denoting a simple action. For one list, participants were requested to enact each sentence, using the specified object (8 s/item). For example, for the sentence ‘Lift the pen’ the experimenter provided the participant with a pen and told him or her to use the object to enact the sentence. The object was removed from sight after each accomplishment. The other list was studied without enactment. The nouns in the sentences were dividable into four semantic categories (e.i., fruits, musical instruments, carpentry tools, and body parts). A free-recall test of the sentences followed. The number of sentences (including the correct verb and noun) recalled under the enacted condition were entered into the analyses.

**Cued recall of nouns.** Following the free recall test, there was a cued recall test of the nouns presented in each of the two lists described above. We had four categories for each of the two lists presented, and the participants were given 3 minutes to recall as many target items as possible from each category. Number of nouns recalled from the enacted condition served as the measure for the analyses.

**Activity recall.** At the end of the memory test session, the participants were asked to describe as accurately as possible all the tasks they had completed during the session. The total number of activities mentioned, as previously performed, was entered into the analyses.

**Recall/divided attention.** Participants were presented with four lists, each of 12 nouns. The items on each list were read aloud by the experimenter at
a pace of 2 s/item. Following presentation of the last item on each list, participants recalled as many of the nouns as possible in any order. For one list, the task was performed under conditions of full attention on study and at retrieval. Study/retrieval of words on the other lists was paired with the performance of a secondary task. This task consisted in sorting red and black cards into two piles on the basis of their colour (2 s/item). Under one condition, division of attention was applied on study of the nouns, but not at retrieval. Under another condition, participants were requested to sort the cards at retrieval of the nouns, but not on study. Under a final condition, both the study and retrieval of words took place with divided attention. Scores from all four conditions were entered into the analyses.

Episodic memory tests: Recognition

Face and name recognition. The participants were shown 16 colour photos with faces of children, along with the first name and family name of each child, and instructed to remember the faces and the family names for a later test. The presentation time was set at 8 s per face and name. Approximately 45 min after this presentation (a period during which other cognitive tests were administered), participants were shown 24 faces at random, including 12 faces from the study phase and 12 new faces. The presentation time was set at 15 s per item. During this time, the participants were asked to identify the face (i.e., yes/no recognition test), the first name, and the family name. For the recognition of names, four alternatives with different combinations of names were presented with each photo. Number of hits minus false alarms for faces, and number of hits for family names were entered into the analyses.

Recognition of nouns. In this task, participants were presented with a list of 32 nouns. Of these, half were new and half were from the enacted/non-enacted sentences studied earlier, with 8 nouns from each condition (the other nouns serving as distracters). The time allowed for recognizing (yes/no) was 5 s per item. Number of hits minus false alarms for nouns from the non-enacted condition served as the measure.

Semantic memory tests

Vocabulary. A modified 30-item multiple-choice synonym test, developed by Dureman (1960), was used (Nilsson et al., 1997). The task was to select a synonym for each target word from among five alternatives. Seven min-
utes were allotted for completing the test. The total number of correctly identified synonyms was entered into the analyses.

**Fluency.** Three fluency tests in which the participants generated as many words as possible in 1 min were used. In the first test, the participants said aloud as many words as possible with the initial letter A. The second test involved producing as many words beginning with M and containing five letters as possible. The third test involved generating as many professions with the initial letter B as possible.

**Engaged lifestyle variables**

**Marital status.** In the social questionnaire administered in the Betula project, participants were asked about their marital status in relation to the four following conditions: (a) married/living together (b) single (c) divorced (d) widowed. This variable was investigated in studies 1 and 3.

**Leisure activity.** Participants were asked to complete a 16-item questionnaire about their leisure activities. Item scores ranged from 1 (never) to 5 (daily). Items included different types of leisure activities, including travelling, taking exercise, reading books, reading magazines, watching TV or listening to radio, going to a restaurant, visiting family and friends, reading newspapers, attending a course or study, attending religious meetings, playing an instrument, working with handicrafts, hunting or fishing, attending to committee work, going to the movies, concerts, or theatre, and other hobbies and activities.

In study 2, two types of activities were considered in the analyses: social activity and cognitive activity. The items for social activity were travelling, going to a restaurant, visiting family and friends, and going to the movies, concerts, or theatre. Reading books and attending a course or study were the items chosen to measure cognitive activity. In study 3, the average of all the item scores was considered as the score for general leisure activity.
III. Results

Study I

Although there are a lot of studies of the relation between marital status and health factors, there are only a few that have specifically examined the relationship between marital status and cognitive functioning. Previous studies have shown inconsistent findings about the relation between marital status and cognition (especially when the MMSE, a general cognitive test, is used). However, most previous studies have focused on dementia by using a general cognitive abilities test (e.g., the MMSE test) (e.g., Van Gelder et al., 2006; Håkansson et al., 2009). But the different types of memory tasks have not yet been studied. In this study, the aim was to examine the effects of marital status and age on specific memory tasks: episodic and semantic. In particular, married people were compared with different groups of non-married people (single, divorced, and widowed) on different episodic (recognition and recall) and semantic (verbal fluency and vocabulary) memory tasks. We were interested in exploring whether memory differs significantly between categories of persons of divergent marital status.

Table 2. General information about participants of each marital status in two age cohorts

<table>
<thead>
<tr>
<th>Age group</th>
<th>Married</th>
<th>Single</th>
<th>Divorced</th>
<th>Widowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle age (35-60 years) N</td>
<td>1026 (510)</td>
<td>77 (40)</td>
<td>76 (57)</td>
<td>30 (24)</td>
</tr>
<tr>
<td>Age at W1 (SD)</td>
<td>48.88 (8.22)</td>
<td>45.52 (8.05)</td>
<td>51.05 (6.99)</td>
<td>56.83 (4.82)</td>
</tr>
<tr>
<td>Education (SD)</td>
<td>11.65 (3.82)</td>
<td>12.94 (4.07)</td>
<td>11.76 (4.71)</td>
<td>8.92 (2.89)</td>
</tr>
<tr>
<td>Leisure activity (SD)</td>
<td>41.88 (5.19)</td>
<td>39.73 (5.44)</td>
<td>41.36 (5.77)</td>
<td>42.35 (5.08)</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>142 (71)</td>
<td>10 (7)</td>
<td>11 (7)</td>
<td>6 (5)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>129 (66)</td>
<td>12 (8)</td>
<td>7 (5)</td>
<td>6 (5)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>21 (10)</td>
<td>1 (0)</td>
<td>2 (2)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Old age (60–85 years) N</td>
<td>396 (163)</td>
<td>31 (23)</td>
<td>34 (23)</td>
<td>212 (186)</td>
</tr>
<tr>
<td>Age at W1 (SD)</td>
<td>70.16 (5.28)</td>
<td>74.84 (5.39)</td>
<td>69.71 (5.36)</td>
<td>74.62 (5.56)</td>
</tr>
<tr>
<td>Education (SD)</td>
<td>8.23 (3.31)</td>
<td>7.88 (2.36)</td>
<td>8.46 (4.16)</td>
<td>7.23 (2.58)</td>
</tr>
<tr>
<td>Leisure activity (SD)</td>
<td>41.37 (5.55)</td>
<td>38.44 (8.11)</td>
<td>42.21 (5.43)</td>
<td>40.59 (5.85)</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>108 (47)</td>
<td>12 (9)</td>
<td>11 (7)</td>
<td>66 (58)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>90 (45)</td>
<td>9 (7)</td>
<td>12 (6)</td>
<td>56 (51)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>28 (8)</td>
<td>3 (2)</td>
<td>3 (1)</td>
<td>18 (15)</td>
</tr>
</tbody>
</table>

Note: For N, cardiovascular disease, hypertension, and diabetes the numbers in the parentheses refer to number of women.
In this study, we performed repeated measures analyses. We explored the influences of marital status on episodic memory and semantic memory separately. A 4 (marital status: married, single, divorced, and widowed) × 2 (age cohort: 35-60 and 65-85) × 2 (Wave: W1 and W2) ANCOVA was conducted for each type of memory function. Education, diseases (cardiovascular diseases, diabetes, and hypertension), chronological age and leisure activity were entered as covariates into all the analyses. The results showed that the main effect of marital status was significant for episodic memory, but not for semantic memory. That is, the married, divorced, and widowed groups performed significantly better on episodic memory than did the singles group. The means of the main effects of marital status on episodic memory are shown in Figure 6. Also, the marital status × wave interaction reached statistical significance. The source of this interaction was a larger drop in episodic memory function between W1 and W2 for the singles group than for the other groups (Figure 7).

![Figure 6. Main effects of marital status on episodic memory performance by group.](image-url)
The same analytic design as for episodic memory was used for semantic memory. This analysis revealed no significant main effects of marital status. Means of the main effects of marital status are shown for semantic memory in Figure 8. But there was an interaction effect of marital status and age. This interaction showed that, in the age group 65-85, married people have better semantic memory performance than widowed people, but there is no difference in the age group 35-60. The means of the interaction effects of marital status and age are shown in Figure 9.

Figure 7. Mean performance z scores on episodic memory for groups of different marital status at Wave 1 and Wave 2.

Figure 8. Main effects of marital status on semantic memory performance by group.
We also conducted a 4 marital status (married, single, divorced, and widowed) × 2 gender (female and male) × 2 wave (W1 and W2) ANCOVA to investigate the interaction effects of marital status and gender on episodic and semantic memory performance and their subtypes. We found no interaction effects of marital status and gender on performance of any of the episodic memory tasks or the semantic memory tasks. The main effects of marital status and gender remained similar to those reported above.

**Conclusions**

In this study, we showed that marital status has a positive impact on episodic memory across adulthood and old age. The findings demonstrate that the well-established positive relation between marriage and health can be extended to marriage and some aspects of cognitive performance. Married individuals show a lesser performance decline on episodic memory tasks. Also, single and widowed individuals are at higher risk of memory decline over time. In other words, not being married or losing a partner can have negative effects on memory in the long run. The robustness of these effects is further evidenced by the absence of any interaction effect of gender or age. The positive influence of marriage on memory performance might be
explained by the impact of challenges involved in relationships with others (partners) on cognitive functioning.

**Study II**

Over the years, there has been an increased interest in investigations of the influences of leisure activity on cognitive performance. Numerous studies have tried to study the unidirectional or bidirectional effect of different types of activities and cognitive performance (e.g., Aartsen, Smits, van Tilburg, Knipscheer, & Deeg, 2002; Ghisletta, Bickel, & Lövdén, 2006). However, in these previous studies, there was no general agreement over the possible influences of activities on cognitive functions, the types of items to be used for each type of leisure activity, and the tasks that measure cognitive performance.

In the present study, by using more specific memory tasks, we explored further the disparity between these earlier studies in terms of the differentiated influences of social and cognitive activities. Social and cognitive activities are two important types of activities, which some studies have shown to be significantly different in terms of cognition (e.g., Niti et al., 2008). We studied both the unidirectional and bidirectional effects of leisure activity and memory performance. Our aims were to establish whether an active lifestyle facilitates memory function, and also whether high memory function facilitates maintenance of an active lifestyle, in a large population-based sample (Nilsson et al., 1997, 2004). In this study, by using structural equation modeling (SEM) we examined the bidirectional influences of different types of leisure activities (cognitive and social activity) and memory performance (episodic and semantic) on three test occasions at five-year intervals.

Cross-lagged analyses using Mplus 5 (Muthen & Muthen, 2007) were performed to examine links between leisure activity, including social and cognitive activities, and different types of memory function, including episodic and semantic memory, in old age. The general schema of our cross-lagged models is shown in the model illustrated in Figure 10.

Regarding the relationships between social activity and episodic memory over time, the results showed that, after controlling for the effects of covariates and associations between episodic memory and social activity and the stability paths, social activity at T1 significantly predicted change in episodic memory at T2 ($\beta = .10$), and social activity at T2 significantly predicted change in episodic memory at T3 ($\beta = .10$). The opposite direction, from episodic memory to social activity, was not significant. None of
the cross-lagged paths between social activity and semantic memory function was significant at either T2 or T3.

Regarding cognitive activity function and episodic memory performance, episodic memory at T1 significantly predicted change in cognitive activity at T2 ($\beta = .22$) and episodic memory at T2 predicted change in cognitive activity at T3 ($\beta = .21$). Also in the model for cognitive activity and semantic memory, none of the cross-lagged paths between cognitive activity and semantic memory function was significant at either T2 or T3. All the cross-lagged paths are shown in Table 2.

Conclusions
This study showed that social activity has a positive impact on the performance of subtypes of episodic memory tasks. We found unidirectional effects of social activity on episodic memory on all test occasions. People with high social activity demonstrate better memory performance over time. Also, episodic memory predicted change in cognitive activity at all test waves. Cognitive stimulation and social support from other persons and the environment may protect people from memory decline. In other words, inadequate social activity can predict episodic memory decline across the life span. Also, good episodic memory performance can have a positive influence, in that it enables greater participation in cognitive activities.

Figure 10. General schema of the cross-lagged models of leisure activity and memory.

Note: Paths from covariates on the latent variables leisure activity T1 and memory T1, associations between indicators of latent variables, and also association among covariates were included in the model, but only cross-lagged, stability paths and correlated change associations are displayed.
Table 3. Cross-path estimates between different types of leisure activity and memory performance.

<table>
<thead>
<tr>
<th>Social activity → Episodic memory</th>
<th>Cross-path estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 → T2</td>
<td>.10***</td>
</tr>
<tr>
<td>T2 → T3</td>
<td>.10***</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Episodic memory → Social activity</th>
<th>Cross-path estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 → T2</td>
<td>.04</td>
</tr>
<tr>
<td>T2 → T3</td>
<td>.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social activity → Semantic memory</th>
<th>Cross-path estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 → T2</td>
<td>.04</td>
</tr>
<tr>
<td>T2 → T3</td>
<td>.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semantic memory → Social activity</th>
<th>Cross-path estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 → T2</td>
<td>.01</td>
</tr>
<tr>
<td>T2 → T3</td>
<td>.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cognitive activity → Episodic memory</th>
<th>Cross-path estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 → T2</td>
<td>-.05</td>
</tr>
<tr>
<td>T2 → T3</td>
<td>-.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Episodic memory → Cognitive activity</th>
<th>Cross-path estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 → T2</td>
<td>.22**</td>
</tr>
<tr>
<td>T2 → T3</td>
<td>.21**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cognitive activity → Semantic memory</th>
<th>Cross-path estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 → T2</td>
<td>.06</td>
</tr>
<tr>
<td>T2 → T3</td>
<td>.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semantic memory → Cognitive activity</th>
<th>Cross-path estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 → T2</td>
<td>.17</td>
</tr>
<tr>
<td>T2 → T3</td>
<td>.16</td>
</tr>
</tbody>
</table>

*Note.* **p < .01    ***p < .001.

**Study III**

We investigated the influences of two important aspects of engaged lifestyle and health as important variables that affect memory performance across ages. We also examined the indirect roles of marriage and leisure activity, via health, in addition to the direct roles of these variables in memory performance. Data came from three waves at 5-year intervals in the Betula project: marital status and leisure activity from Time 1, health from Time 2, and episodic memory performance from T3 (Figure 11).
Using structural regression modeling (SRM), we found that health significantly predicted episodic memory performance ($\beta = .10$). People who reported better health demonstrated better episodic memory performance 5 years later. Marriage directly predicted episodic memory performance, and leisure activity directly predicted health. Regarding the indirect effects of marital status and leisure activity on memory performance via health, the results demonstrated that health mediated the influence of leisure activity on episodic memory function ($\beta = .02$). The indirect effect of marital status on memory function via health was non-significant.

**Conclusions**

We conclude that engaged lifestyle, as measured by marriage and leisure activity, is an important factor in protecting individuals from memory deficit and decline. Identification of the possible mechanisms behind the protective effects of marriage and leisure activity may have important implications for intervention and protection against memory decline. Marriage directly, and leisure activity indirectly via health, can protect people from cognitive problems later on.

*Figure 11. The times of measurement of the main variables in the study.*
IV. Discussion

The primary purpose of this dissertation was to gain better knowledge of the effects of some indicators of engaged lifestyle on memory performance. The two important aspects of engaged lifestyle that have been studied in this dissertation are marital status and leisure activity. An additional focus was on the possible mechanisms underlying the effects of engaged lifestyle on memory function. The dissociation between episodic and semantic memory in relation to engaged lifestyle was also investigated.

In the first study, based on data on more specific memory tasks, it was demonstrated that single individuals are at higher risk of memory deficit than are other types of non-married individuals. Previous research has found differences between the married and singles and widowed in relation to dementia and a global cognitive task (measured by the MMSE), but we have extended these findings to more specific episodic-memory tasks in a healthy and normal population. It should be noted that, although some previous research (e.g., van Gelder et al., 2006) has found cognitive differences between married people and different groups of non-married people (single, divorced, widowed), we found that such differences are mainly between married and singles, and not between married and divorced/widowed people. Thus, it seems that it is not appropriate to deal with different categories of non-married groups in one and the same way.

In this study, we found no interaction between marital status and gender in relation to memory performance. Previous research has shown that females generally outperform males on memory tasks, especially with regard to episodic memory (Herlitz et al., 1997), and also that marriage has a stronger positive effect on men’s health than on women’s health (Janicki et al., 2005). However, it was found that married men and women, in general, demonstrate better memory performance than unmarried men and women. This means that the effect of marriage on memory is robust, and can be observed in both the genders.

In the second study, our results extended findings of the positive effects of social leisure activities on cognition found in previous studies to more specific memory systems and subsystems. To our knowledge, no previous longitudinal study has investigated the relationship between activity and memory over 10 years, and across a relatively large age range, with regard to specific categories of activities. Our findings, in line with use-it-or-lose-it hypothesis, indicate that individuals with a socially more engaged lifestyle tend to have better memory function. In the literature, it has also been shown many times that there is a link between level of participation in
activities and performance on various cognitive tasks, in both longitudinal studies (Ghisletta et al., 2006; Lövdén et al., 2005; Newson & Kemps, 2005), and cross-sectional studies (e.g., Christensen et al., 1996; Hill, Wahlin, Winblad, & Bäckman, 1995; Luszcz, Bryan, & Kent, 1997).

In line with the use-it-or-lose-it hypothesis, some studies (e.g., Niti et al., 2008; Verghese et al., 2003; 2006) have demonstrated that there is an association between cognitive activity and memory performance. Intellectually stimulating activities, such as reading, playing mental games, and doing crossword puzzles, have been found to be associated with reduced dementia risk (Kawashima et al., 2005; Wilson et al., 2002). However, our results do not reflect this finding. In line with the preserved differentiation hypothesis, we found that episodic memory can positively predict changes in cognitive activity. This finding demonstrates that, as suggested by Salthouse (2006), active individuals are likely always to have had higher levels of cognitive functioning, and that their enduring higher cognitive function allows them to be more active in old age. Also, Aartsen and colleagues (2002) found a unidirectional positive effect of one type of cognition (information-processing speed) on developmental activity (with one item: attending a course or studying) in a longitudinal study.

However, questions remain as to why there is an effect of episodic memory on cognitive activity but not on social activity, and why social activity is predictive of episodic memory while cognitive activity is not. On the basis of the literature, it seems that the discussion about the relationship between activity engagement and cognitive performance initially had a greater concentration on cognitive activity. For example, most of the works suggested by Salthouse have focused on the role of mental activity, not on other types of activities, like social or physical activities. It seems that, in recent years, hypotheses in this field have been extended to social and physical activities as well. Therefore, it is possible that certain types of activities have more of a relationship with certain specific hypotheses. In such case, our results show that the use-it-or-lose-it hypothesis is more important for social activity, whereas the relationship between cognitive performance and cognitive activity is more consistent with the preserved differentiation hypothesis. We have considered both hypotheses simultaneously. In line with our speculation, although some longitudinal studies (Ghisletta et al., 2006; Lövdén et al., 2005) have shown that activity can have a positive influence on cognitive performance, their results focus on participation in social activity. Some other researchers (Newson & Kemps, 2005; Mackinnon et al., 2003) have also found an effect of general activity on cognitive performance, not effects of certain types of activities. Accordingly, we believe that, although social activity can be seen as a protective
factor against cognitive decline, having good cognitive performance, in turn, is a predictor of cognitive activity. However, we should be cautious in drawing any definite conclusions.

In the third study, the indirect effects of leisure activity and marital status on memory function via health, as well as the direct effects of these two important aspects of engaged lifestyle, were investigated. We found that the positive effect of marriage on memory function was direct; the married people performed better on episodic memory 10 years later than did the single people. However, our results also show significant indirect effects of leisure activities on episodic memory performance via health. Some studies have suggested that engaging in different types of activities has benefits for physical and psychological health. The health benefit of activity, especially physical activity, are substantial in terms of the cardiorespiratory system, reduction in or control of hypertension, improved tolerance of stress, and reduction in poor health habits, including cigarette smoking, alcohol consumption, and poor diet (Taylor, 2006). Previous studies have demonstrated that people who attend cultural events regularly have lower mortality (Bygren, Knlaan, & Johansson, 1996). Cognitive, physical, and social activities have good influences on psychological states, such as mood, anxiety, depression, and tension (e.g., Wada et al., 2004). So we can conclude that leisure activity has an effect on health, and health has an effect on cognitive function. Thus, leisure activity is an important determinant of health, which, in turn, is an important determinant of episodic memory.

Our knowledge of the exact mechanisms via which engaged lifestyle impacts on memory performance is still scanty. There is a possibility that several potential mechanisms can explain the association between engaged lifestyle and memory performance. Fratiglioni and her colleagues (2004) believe that most of the common pathways between engaged lifestyle and cognitive function can be encapsulated in three major hypotheses: the cognitive reserve hypothesis, the vascular hypothesis, and the stress hypothesis.

The cognitive reserve hypothesis is that certain aspects of life experience, such as occupation, amount of education, and engaged lifestyle, provide individuals with a cognitive reserve that makes them less sensitive to and better able to cope with cognitive pathology (Stern, 2002). An engaged lifestyle might provide greater readiness for compensatory changes in response to neurophysiological decline (Stern, 2002). Participation in cognition stimulating activities may boost neuronal growth and maintenance, and thereby protect the brain from degeneration and subsequent cognitive decline. In line with this hypothesis, we found a greater risk of memory decline in singles, compared with married people or even with other non-
married groups (divorced and widowed). Thus, being married in general, currently or previously, has important intrinsic cognitive components, and results in ongoing cognitive engagement, or contributes to better cognitive functioning. It is interesting to mention that, although divorced people have negative emotionally experiences, the cognitive stimulation, although a negative one, may still have a positive influence on memory performance. In other words, cognitive stimulation, good or bad, protects against memory decline.

According to the vascular hypothesis, engaged lifestyle acts on cognitive function via the beneficial effects of the absence of cardiovascular diseases and stroke. Since we controlled for the effects of heart disease and hypertension, and also excluded people who had been diagnosed with stroke, in all the studies, the unique effect of this hypothesis is not confirmed. It seems that the effect of engaged lifestyle on memory performance goes beyond the mediating role played by vascular diseases.

The final hypothesis is related to the fact that the benefit of engagement in social activities is associated with higher social support from other people, which decreases depression, and the adverse effects of stress and the associated elevation of cortisol (Bassuk, Glass, & Berkman, 1999). In general, it may a combination of several mechanisms that can directly or indirectly account for the positive effect of engaged lifestyle on memory performance.

According to Berkman and colleagues (2000), social networks operate through five principal mechanisms – social support, social influence, social engagement, person-to-person contact, and access to resources and material goods – in shaping the health of individuals. In turn, these mechanisms impact on health along three pathways: behavioural, physiological, and psychological. On the other hand, the effects of engaged lifestyle on cognitive aspects have been identified in the literature. Accordingly, we developed a conceptual model of the relationship between engaged lifestyle and memory function. We extended the model of a positive impact of engaged lifestyle on health (via physiological, psychological, and behavioural pathways) to a wider model concerned with engaged lifestyle, health, and cognition. There is the possibility that each aspect of engaged lifestyle has a more specific impact on some of the pathways that link engaged lifestyle and health. For example, the psychological pathway involving social activity may be a more effective one to take than the behavioural pathway. It should also be noted that there may be differences between the various indicators of engaged lifestyle along the pathways that link to health. For example, the role played by marriage in health via the behavioural pathway may be more important than that played by leisure activity. Our ex-
tended conceptual model, which is shown in Figure 12, can be used for more detailed investigation in future research.

Based on the findings of previous research (Nilsson, 2003), we expected that the relationship between engaged lifestyle and memory would be more pronounced in episodic memory than in semantic memory. Whereas episodic memory is about remembering episodes or events from the personally experienced past, and exists in time and space, semantic memory is about general knowledge without a specific time or place. Episodic memory is a recently evolved, late-developing, and early-deteriorating past-oriented memory, which is more vulnerable than other memories to neuronal dysfunction (Tulving, 2002). Evidence that declarative memory can be divided into two different systems comes from many sources (see Nyberg & Tulving, 1996, for a review). Some neuroimaging and lesion studies have demonstrated that the neural bases of episodic and semantic memory differ from each other (see Mayes & Montaldi, 2001; Moscovitch et al., 2006, for a review). Also, a variety of correlational studies using different statistical techniques, such as structural equation modeling (SEM), show findings consistent with the notion of dissociation between the episodic and semantic memory systems (Nyberg, 1994; Nyberg et al., 2003). Some researchers have indicated that aging does not impair all declarative memory functions equally. Rather, aging seems to have more negative effects on episodic memory than on semantic memory (e.g., Nyberg et al., 2003). Further, previous studies have shown that females perform at a higher level than males on episodic memory tasks, although there is no difference between males and females on semantic memory tasks (e.g., Herlitz et al., 1997). Previous research has also indicated that some genetic factors, like apolipoprotein ε4 (APOE-ε4), do not have a general effect on memory performance. Rather, the magnitude of APOE-ε4 related deficits is primarily observed in tests of episodic memory, and only small effects are detectable in tests of semantic memory (Nilsson et al., 2006). In the studies encompassed by this dissertation, in line with the above-mentioned research, we also found dissociation between episodic memory and semantic memory on the basis of engaged lifestyle (studies I and II). Episodic memory is more sensitive to marital status than semantic memory. Married people demonstrate better episodic memory performance than single people. And, whereas the extent of episodic memory decline was found to be greater for single and widowed people than for married people, no such differences were observed in the case of semantic memory. Also, a positive effect of social leisure activity was seen on episodic memory but not on semantic memory. We found that social activity was a longitudinal predictor of episodic memory performance, but there was no influence of social activity on se-
mantic memory function. In sum, the dissociation between episodic and semantic memory that we found in our studies confirms Tulving’s (1972) view on memory systems in terms of engaged lifestyle effects. In other words, there are separate memory systems in the brain that have different structures and function.

Figure 12. Our extended conceptual model of engaged lifestyle, health, and cognition.
Limitations

There are some limitations to the studies. In the first study, the effect of marital status on memory performance was investigated. However, one of the important issues here is marriage satisfaction. We did not have any information about satisfaction in the Betula project. However, we made an attempt to compensate for this disadvantage by using longitudinal data. That is, only people who had the same marital status for 5 years were selected in the different categories, i.e., married-married, single-single, divorced-divorced, and widowed-widowed. Accordingly, it can be supposed that there was some degree of marital satisfaction in that our married people maintained their married status for this period of time.

We were interested in investigating the three-way interaction effects between marital status, age, and gender, but since the number of participants in some cells was too small, especially in the unmarried group, we were not able properly to examine this issue.

One limitation of study II was that we had only two items to measure cognitive activity, and they may not be representative of cognitive activity overall. Future work in this field of research needs to consider this issue by analysing more items. It should be noted that this problem is related to a more general issue regarding the leisure-activity questionnaire. The questionnaire had sixteen items, covering different aspects of leisure activity. There were not enough items for some categories of leisure activities, especially physical activity. In fact, only one item was directly concerned with physical activity. A scale with more items about different categories of leisure activities would better illuminate the reciprocal effects of leisure activity and cognition. This is a task for future research.

In study III, we did not find any relationship between marriage and health. Also, health did not mediate the effect of marital status on episodic memory performance. This result may be related to the scale of our health variable, since we examined the roles played by some aspects of subjective health. We propose that future studies should examine the mediating role of health in memory performance by using other scales, such as objective health, or some aspects of emotional health, like subjective well-being. According to the World Health Organization’s (WHO) definition, health is ‘a complete state of physical, mental, and social well-being and not merely the absence of disease or infirmity’ (World Health Organization, 1948). Rather than defining health as the absence of illness, it can be regarded as an achievement, involving the balancing of physical, mental, and social well-being. Although health was investigated in an exclusively negative
direction in this research, questionnaires with positive health items should be used in future studies.

**Implications**

Most predictors of cognitive decline that have been identified so far are fixed or not readily modifiable, such as gender, low level of schooling, impaired hearing and vision, genetic factors, and impairments to health (Anstey & Christensen, 2000). Most of these predictors do not suggest areas for delaying the cognitive deficit (at least at the present time), either because they reflect early life experiences or genetic factors, or because they are not readily avoidable. By contrast, aspects of engaged lifestyle are potentially alterable (Mackinnon et al., 2003). In general, there is evidence that a socially engaged and active lifestyle protects the individual against memory decline. This hypothesis is demonstrated in a general model of dementia occurrence that takes into account the effects of protective factors and risk factors acting at different times during the life course (see Figure 13; Fratiglioni, Paillard-Borg, & Winblad, 2004). It is now recognized that social relationships and affiliations have powerful effects on physical and mental health. Social isolation and depression affect one in seven people over 65, and there is an increasing recognition that social isolation negatively affects long-term health. Research indicates that the interventions which promote active social contact, which encourage creativity, and which use mentoring are more likely positively to affect health and well-being (Greaves & Farbus, 2006).

Engaged lifestyle can be seen as a potential benefit in an intervention, especially for old people. Older individuals have often been excluded from health promotion interventions, and preventive measures in health care usually focus on people up to middle age (Agahi, 2008). On the basis of the positive effects of activity on physical and mental health and cognitive performance, health promotion programs designed for older people would be of value.

As mentioned in the introduction, according to Rowe and Cahn (1997), successful aging is defined as having three components: a low probability of disease, high physical and cognitive functional capacity, and engagement with life. In line with this definition, some previous studies (e.g., Habib, Nyberg, & Nilsson, 2007) have differentiated between usual aging and successful aging. Habib and colleagues (2007) found that length of formal education is the best predictor of high functioning elderly individuals, who remain highly functional and have aged successfully. Although the aim of these studies was not to define successful aging or find the predictors or
Determinants of successful aging, our results can be interpreted as meaning that being married and being highly active in life can be regarded as predictors of successful aging.

Our results provide further support for an association between activity and health. In general, leisure activities seem to promote health over a long period of time. Thus, activity engagement may be recommended as a powerful intervention modifies the rate of age-related changes in cognitive function and reduces the risk of memory decline among adults.

We suggest that interventions or activities that enhance social support would improve cognitive functions in the elderly. It seems that social ties, social networks, and/or social support, which marriage often provides, and perceived positive support from friends significantly and positively influence cognitive function.

Figure 13. The timeline of risk factors and protective factors for dementia. The ages to which each factor applies are identified in available studies (from Fratiglioni, Paillard-Borg, & Winblad, 2004). Reprinted with the permission of Elsevier Publishers.
Future research

Some questions remain for future research. We have studied the role played by engaged lifestyle in memory function in adulthood, and especially during old age. One question is whether engaged lifestyle is important across the whole life span or only during adulthood. Some other variables may moderate or mediate the relationship between engaged lifestyle and memory performance, such as genetic factors, personality, or intelligence. Future research might fruitfully examine possible interactions between these variables. Culture is another variable that can be considered in the relationship between engaged lifestyle and memory performance. Previous research has uncovered cultural differences in a wide range of psychological domains, such as cognition, emotion, and psychological well-being (Lehman, Chiu, & Schaller, 2004; Oyserman, Coon, & Kemmelmeier, 2002). Accordingly, it is possible that leisure activity in general, and social activity in particular, have different meanings in different cultures. How to find corresponding definitions and items of leisure activity in different cultures, and their different possible mechanisms in relation to health and cognition, should be addressed in future studies.

Although we did not specifically study the effect of physical activity in our studies, its role – alongside cognitive and social activity – is important. The positive influences of physical activity on health and cognition have been supported in the literature (see Fratiglioni, Paillard-Borg, & Winblad, 2004, for a review). Physical activity decreases the risk of cardiovascular disease and improves survival after a cardiovascular event (Bassey, 2000). Such a positive effect has been shown in both middle age and old age (Mensink, Ziese, & Kok, 1999), and in both men (Wannamethee, Shaper, & Walker, 1998) and women (Kushi et al., 1997). Beneficial effects of physical exercise have been reported in relation to several diseases, such as obesity, diabetes, hypertension, osteoporosis, and depression (Bassey, 2000; Wannamethee, Shaper, & Alberti, 2000; Strawbridge, Deleger, Roberts, & Kaplan, 2002). There are also a number of reports showing that the prevalence of dementia is lower among people who engage in more physical exercise (see Colcombe & Kramer, 2003). As mentioned above, although there are plenty of studies in the literature of the role of physical activity on cognition, it can be studied using more specific cognitive tests, such as those of episodic and semantic memory, and longitudinally by using more complicated statistical methods like structural equation modeling. Future studies might investigate the direct effects of physical activity on memory function, and also the indirect effects via health. Consideration of these issues will help us better to define the target populations for future
specific interventions, and consequently better to delineate preventive and therapeutic strategies.

**Conclusions**

Over the past three decades, extensive research has increased our knowledge of the risk and protective factors involved in memory decline and Alzheimer’s disease. A variety of hypotheses have already emerged from the epidemiological literature. The aims of the present dissertation are to shed some light on engaged lifestyle, and to examine its relationships with memory performance and health.

The overall results indicate that an active and engaged lifestyle results in better memory performance. Specifically, married people have better episodic memory function than single people. Also, the extent of decline is significantly lower for married individuals than for single and widowed individuals. Also, social activity positively predicts episodic memory performance over the life span. Good episodic memory performance, in turn, can also have a positive influence on cognitive activity. Our results show that the positive effect of leisure activity on memory performance is mediated by health. To conclude, active and engaged lifestyles can protect people from memory decline.
V. References


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