Leisure activities and cognitive function in middle age: evidence from the Whitehall II study

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See end of article for authors’ affiliations

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Evidence of individual differences in the rate of cognitive aging has led to research into factors that might delay cognitive decline in old age. Investigation in this domain is based on the premise that cognitive ability is not “fixed”, and that environmental factors play a part in maintaining and augmenting cognition in adulthood. The protective effect of high socioeconomic position has been widely recognised.1–4 Increasingly, attention is being paid to lifestyle variables that might be beneficially related to cognitive function.5–8 However, relevant research evidence is difficult to interpret as some studies that show a protective effect of lifestyle variables have included SES as a measure of lifestyle.24 When SES is used to define an “active” lifestyle an association with cognitive function would simply suggest that high SES individuals seek more stimulating environments leading to the preservation of their mental faculties for longer. It is therefore essential to examine the effect of lifestyle variables while controlling for the effects of SES.

Lifestyle is seen to represent a number of different constructs—social support,6 social network,7 8 social/leisure activities,9 10 11 physical exercise/sports activity,12 13—and there is some support for a positive association with cognitive function for all of them. In some studies composite indices that combine measures of social network, social support, marital status, and social activities have been used,9 making it impossible to identify specific beneficial lifestyle variables. However, it is generally accepted that participation in complex activities is beneficial to maintenance of cognitive ability in adults.12 13 In this study we first test the hypothesis of a SES adjusted, positive association between participation in leisure activities and cognition. Then we explore the “complexity” hypothesis by classifying leisure activities in two ways: first as requiring either high or low cognitive effort and then as being either individual or social activities. There is already some evidence to show that activities with higher cognitive demand have a more robust association with cognition,10 14 15 leading us to expect the same in our sample. Participation in social as compared with individual activities captures the complexity hypothesis in terms of social engagement and the link with cognition will be explored here.

METHOD

Study population

The Whitehall II study

The Whitehall II study was established in 1985 as a longitudinal study to examine the socioeconomic gradient in health and disease among 10 308 civil servants (6895 men and 3413 women).16 All civil servants aged 35–55 years in 20 London based departments were invited to participate by letter. In total, 73% of those invited agreed to take part in phase 1. Response rate at baseline varied by employment grade, being 81% among the top three employment grade categories and 68% among the lower three categories. Baseline examination (phase 1) took place during 1985–1988, and entailed a clinical examination and a self administered questionnaire containing sections on demographic characteristics, health, lifestyle factors, work characteristics, social support, and life events. Clinical examination included measures of blood pressure, anthropometry, biochemical measurements, neuroendocrine function, and subclinical markers of cardiovascular disease. Subsequent phases of data collection have alternated between postal questionnaire alone and postal questionnaire accompanied by a clinical examination. Since baseline five phases of data collection rounds have been completed, with
the most recent phase of data collection (phase 6) completed in 2001. A battery of cognitive tests was introduced to the study midway through phase 3, consequently cognitive data are available on 40% of available sample at phase 3 and the entire sample at phase 5 of data collection. Data for the analyses reported here are drawn from phase 5 (1997–1999) as the activity questionnaire was introduced to the study only at phase 5.

Measurement of socioeconomic status
Three measures were used to assess SES. These were: Education, measured as the highest level of education achieved, with the respondent choosing one of 11 categories in the questionnaire. This was regrouped into five standard hierarchical levels: (1) no formal education, (2) lower secondary education, (3) higher secondary education, (4) university degree, (5) higher university degree.

Occupation, assessed via civil service employment grade. All jobs in the civil service have a grade of employment. Employment grade of participants included in this study ranges from grade 1 to grade 6, with grade 1 representing the highest level and grade 6 the lowest. People in different grades differ with respect to salary, social status and level of responsibility. On 1 January 1987 salaries ranged from £62 100 for grade 1 to £3061 for grade 6. For analyses presented in this paper employment grade has been recoded so that 6 represents high grade and 1 represents low grade.

Income, assessed via a question asking respondents to pick a category that corresponded most closely with their annual personal income (‘‘amount received annually from salary or wages, or pensions, benefits and allowances before deduction of tax’’). There were eight categories, ranging from ‘‘less than £9999’’ to ‘‘more than £70 000’’. For the purposes of analysis the two highest and the two lowest personal income categories were collapsed to leave six categories. These categories are as follows, £0–£50 000; 5 = £35 000–£49 999; 4 = £25 000–£34 999; 3 = £20 000–£24 999; 2 = £15 000–£19 999; and 1 ≤ £14 999.

Measurement of cognitive function
The cognitive test battery consisted of five standard tasks chosen to provide a comprehensive assessment of cognitive function.

Verbal memory test was assessed by a 20 word free recall test of short term memory. Participants were presented with a list of 20 or two syllable words at two second intervals and were then asked to recall in writing as many of the words in any order within two minutes (maximum possible score = 20, mean = 6.86, SD = 2.45).

The AH 4-I,17 is composed of a series of 65 items—32 verbal and 33 mathematical reasoning items of increasing difficulty. This is a test of inductive reasoning that measures the ability to identify patterns and infer principles and rules. Participants had 10 minutes to complete this section (maximum possible score = 65, mean = 46.45, SD = 11.32).

The Mill Hill Vocabulary test,19 assesses knowledge of verbal meaning and encompasses the ability to recognise and comprehend words. We used the test in its multiple format, which consists of a list of 33 stimulus words ordered by increasing difficulty, and six response choices per word (maximum possible score = 33, mean = 23.86, SD = 5.26).

Two measures of verbal fluency20 phonemic and semantic. Phonemic fluency was assessed via ‘‘S’’ words and semantic fluency via ‘‘animal’’ words. Subjects were asked to recall in writing as many words beginning with ‘‘S’’ (mean = 16.83, SD = 4.45) and as many animal names as they could (mean = 16.37, SD = 4.21). One minute was permitted for each test.

Measurement of leisure activities
Information was collected on 13 leisure activities as part of a larger self administered questionnaire. The frequency with which participants engaged in these activities was measured on a 4 point Likert scale: 0—never, 1—rarely, 2—monthly, 3—weekly. These activities were grouped in three ways. Firstly, scores on all activities were combined to obtain a ‘‘composite index’’ of participation in leisure activities (maximum possible score = 39, mean = 15.44, SD = 4.95). Then, two independent raters classified these activities twice (see table 1). In the first instance activities were classified as either entailing high or low cognitive effort. Activities that could be considered to involve intellectual/developmental activity, cultural activity or require some cognitive effort were categorised as being in the ‘‘high cognitive effort’’ group (seven activities in all, maximum possible score = 21, mean = 6.94, SD = 2.99). Other activities were classified as requiring ‘‘low cognitive effort’’ (six activities in all, maximum possible score = 18, mean = 6.18, SD = 2.98) if they entailed engagement with others, if not they were classified as ‘‘individual activities’’ (seven activities in all, maximum possible score = 21, mean = 9.05, SD = 3.33). There was no disagreement

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Age adjusted means on leisure activities for men and women†‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leisure activities</td>
<td>Alternate classification‡</td>
</tr>
<tr>
<td>Activities entailing low cognitive effort</td>
<td>1 Household tasks, for example, DIY (do it yourself), maintenance, decorating</td>
</tr>
<tr>
<td></td>
<td>2 Practical activities, making things with your hands, for example, pottery, drawing, etc.</td>
</tr>
<tr>
<td></td>
<td>3 Gardening</td>
</tr>
<tr>
<td></td>
<td>4 Visiting friends and relatives</td>
</tr>
<tr>
<td></td>
<td>5 Going to pubs and social clubs</td>
</tr>
<tr>
<td>Activities entailing high cognitive effort</td>
<td>6 Religious activities/observance</td>
</tr>
<tr>
<td></td>
<td>7 Using a home computer for leisure</td>
</tr>
<tr>
<td></td>
<td>8 Cultural visits to stately homes, galleries, theatres, cinema, or live music events</td>
</tr>
<tr>
<td></td>
<td>9 Social indoor games, cards, bingo, chess, etc.</td>
</tr>
<tr>
<td></td>
<td>10 Individual occupations, for example, reading, listening to music</td>
</tr>
<tr>
<td></td>
<td>11 Political activities, for example, attending meetings, meetings of local groups</td>
</tr>
<tr>
<td></td>
<td>12 Involvement in clubs and organisations, voluntary, or official.</td>
</tr>
<tr>
<td></td>
<td>13 Courses and education/evening classes</td>
</tr>
</tbody>
</table>

*Response on 4 point Likert scale, 0—never, 1—rarely, 2—monthly, 3—weekly. †There were no sex differences in participation in leisure activities, F (13, 5337) = 1.51, p = 0.11. ‡Leisure activities also classified as being individual (I) activities (items 1, 2, 3, 6, 7, 10, 13) or social (S) activities (items 4, 5, 8, 9, 11, 12).

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between the raters concerning the first system of classification. However, both item 6 and 13 on table 1 were seen to social activities by one of the raters. The final decision on these items was made in consultation with the authors of this paper.

**Statistical methods**

The first set of analysis entailed hierarchical multiple regressions with cognitive function tests as outcome variables. The order of entry of the predictor variables was as follows: age, followed by the SES variables and finally the activity variable. The second set of analysis was carried out on the activities categorised first as involving high or low cognitive effort. All observed variables are in boxes, unobserved variables and error terms are in ellipses. a, b, c, d, e, f, g, h, and I represent standardised regression coefficients (see table 4 for results). The analysis was carried out using AMOS version 4.01. Model fit was assessed using multiple criteria as the statistic is overly sensitive to model misspecification when the sample sizes are large. We used root mean square error of approximation (RMSEA) and comparative fit index (CFI) to assess model fit. An RMSEA value close to zero and a CFI value close to 1 indicates a good fitting model. The AMOS program permits maximum likelihood estimation based on incomplete data, known as full information maximum likelihood estimation (FIML). This approach is based on the direct maximisation of the likelihood of all observed data, not just from cases with complete data. FIML is preferable to estimation based on complete data (the listwise deletion approach) as FIML estimates will show less bias and be more reliable than the listwise deletion approach even when data deviate from missing at random and are non-ignorable. The results were checked using asymptotically distribution free methods (as some of the data are not normally distributed) and similar results to FIML were found.

Sex differences in the model were examined using multi-group analysis in a two step procedure. Firstly, the models were estimated separately for men and women and then the analysis was repeated with the pathways in the two groups constrained to be equal in men and women. Post hoc comparisons in model fit were used to identify which parameters differed significantly between men and women.

**Missing data**

The Whitehall II study had a total of 10 308 respondents at phase 1 of data collection. The median length of follow up from phase 1 to phase 5 was 11 years, with 355 people dying during this period. Altogether 7830 respondents answered the questionnaire at phase 5 and 6531 attended the clinical examination where cognitive tests were administered. Some 6073 of those attending the clinic did at least one cognitive test, 5380 did them all with non-response here clearly influenced by low cognitive scores. In all, we had complete data on the activities questionnaire and all cognitive function tests on 5352 respondents. With respect to baseline, available data were influenced by age (p = 0.001) and employment grade (p = 0.001) but not sex (p = 0.61). Attrition rate was higher among older respondents and low SES groups.

**RESULTS**

Descriptive analyses related to the different leisure activities are presented in table 1. In this sample gardening, visiting friends/relatives, and reading/listening to music were frequent leisure activities. There were no sex differences in the frequency of participation in leisure activities. Table 2 presents the age and SES adjusted effects of the composite index of leisure activity and subsequently, each activity on different measures of cognitive function. All effects are reported using standardised regression coefficients, also known as “betas” (see table 2). These coefficients are calculated from standardised data and reflect the impact on the outcome variable of a change of one standard deviation in the predictor variables. For example, an increase of one standard deviation in the index of leisure
Table 2  Age and SES adjusted effects† of individual activity items on cognitive function

<table>
<thead>
<tr>
<th>Activity Item</th>
<th>Memory M</th>
<th>Memory F</th>
<th>AH 4 M</th>
<th>AH 4 F</th>
<th>Mill Hill M</th>
<th>Mill Hill F</th>
<th>Phonemic fluency M</th>
<th>Phonemic fluency F</th>
<th>Semantic fluency M</th>
<th>Semantic fluency F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite index of leisure activity</td>
<td>0.07**</td>
<td>0.07**</td>
<td>0.13***</td>
<td>0.08***</td>
<td>0.09***</td>
<td>0.03</td>
<td>0.08***</td>
<td>0.08**</td>
<td>0.13***</td>
<td>0.07**</td>
</tr>
<tr>
<td>Household tasks, for example, DIY, maintenance, decorating</td>
<td>-0.01</td>
<td>-0.03</td>
<td>0.06**</td>
<td>0.02</td>
<td>0.00</td>
<td>-0.07***</td>
<td>0.00</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Practical activities, making things with your hands, for example, pottery, drawing, etc</td>
<td>0.01</td>
<td>0.01</td>
<td>0.06**</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Gardening</td>
<td>0.00</td>
<td>0.05**</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.02</td>
<td>-0.06**</td>
<td>0.01</td>
<td>0.03</td>
<td>0.00</td>
<td>0.03</td>
</tr>
<tr>
<td>Visiting friends and relatives</td>
<td>0.00</td>
<td>0.01</td>
<td>0.05**</td>
<td>0.07**</td>
<td>0.03**</td>
<td>0.02</td>
<td>0.01</td>
<td>0.03</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>Going to pubs and social clubs</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.06**</td>
<td>0.04**</td>
<td>0.03**</td>
<td>0.03</td>
<td>0.01</td>
<td>0.03</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>Religious activities/observance</td>
<td>0.00</td>
<td>0.03</td>
<td>0.02</td>
<td>0.04**</td>
<td>0.00</td>
<td>0.02</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>Using a home computer for leisure</td>
<td>0.02</td>
<td>0.02</td>
<td>0.06**</td>
<td>0.05**</td>
<td>-0.01</td>
<td>-0.04**</td>
<td>0.01</td>
<td>0.04</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Cultural visits to stately homes, galleries, theatres, cinema, or live music events</td>
<td>0.06***</td>
<td>0.04</td>
<td>0.10***</td>
<td>0.04*</td>
<td>0.16***</td>
<td>0.11</td>
<td>0.08***</td>
<td>0.09***</td>
<td>0.09***</td>
<td>0.13***</td>
</tr>
<tr>
<td>Social indoor games, cards, bingo, chess, etc</td>
<td>0.05**</td>
<td>0.04</td>
<td>0.08***</td>
<td>0.05**</td>
<td>0.00</td>
<td>0.02</td>
<td>0.06***</td>
<td>0.06**</td>
<td>0.06**</td>
<td>0.06**</td>
</tr>
<tr>
<td>Individual occupations, for example, reading, listening to music</td>
<td>0.05**</td>
<td>0.08**</td>
<td>0.05**</td>
<td>0.05**</td>
<td>0.15**</td>
<td>0.13**</td>
<td>0.04**</td>
<td>0.06**</td>
<td>0.08**</td>
<td>0.06**</td>
</tr>
<tr>
<td>Positions of office, school governor, councillor, etc</td>
<td>0.01</td>
<td>0.04</td>
<td>0.03</td>
<td>0.04</td>
<td>0.01</td>
<td>0.00</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td>Involvement in clubs and organisations, voluntary or official</td>
<td>0.04**</td>
<td>0.06**</td>
<td>0.07**</td>
<td>0.04*</td>
<td>0.05**</td>
<td>0.02</td>
<td>0.04**</td>
<td>0.01</td>
<td>0.08**</td>
<td>0.00</td>
</tr>
<tr>
<td>Courses and education/evening classes</td>
<td>0.04*</td>
<td>0.01</td>
<td>0.04**</td>
<td>0.02</td>
<td>0.07***</td>
<td>0.05**</td>
<td>0.03*</td>
<td>0.04</td>
<td>0.08**</td>
<td>0.05*</td>
</tr>
</tbody>
</table>

†Effect represented as β (standardised regression coefficient). p<0.05, **p<0.01, ***p<0.001.
DISCUSSION

We examined the association between participation in leisure activities and cognitive function in a large cohort study. Cognitive function was assessed comprehensively in this study with measures on memory, verbal fluency, fluid (AH 4) and crystallised intelligence (Mill Hill). The overall “index of participation in leisure activities” was significantly related to cognitive function. Examination of leisure activities, one at a time, shows some activities to have a stronger relation with cognitive function than others. Activities that show a link with cognition entail investment in personal development (cultural visits, individual occupations like reading, courses and evening classes), social engagement (social indoor games) and involvement in the community (involvement in clubs and organisations, voluntary or official).

Separation of leisure activities into low or high cognitive effort categories clearly shows that participation in the latter has a beneficial association with cognitive function. A closer look at the individual effects of the activities that make up the high effort index suggests that not all items in this category have a significant relation with measures of cognitive function. Using a home computer for leisure and occupying positions of office (school governor councillor, etc) have only a limited association with cognitive function. Classification of leisure activities into individual and social activities shows social activities to have a stronger and more consistent relation with cognition. Our results clearly support the hypothesis that social engagement has a positive association with cognition even though the size of the association is weaker than that between cognitively complex activities and cognitive ability.

Studies in this area have not explicated the mechanisms by which leisure activities would have an effect on cognition. This has led different researchers to use different criteria to categorise items. Elwood and colleagues used factor analysis to categorise 18 leisure items into four groups: social, cultural, physical, and intellectual.10 Aartsen et al used inter-rater agreement to develop three categories: social, experiential, and developmental.23 Other studies have used a composite index of participation in social and leisure activities.22 As the association between certain types of leisure activities and cognitive function seems to be robust, attention needs to be paid to underlying mechanisms. We hypothesised that participation in complex activities, both socially complex and cognitively complex, is beneficial as it requires a greater mobilisation of cognitive faculties resulting in their preservation for a longer period. Like education and occupation, participation in demanding leisure activities would augment brain reserve capacity,14–25 which may offer protection from cognitive decline in old age.

The importance of controlling for SES when examining the association between leisure activities and cognition is clearly demonstrated by the strength of the association between SES and cognition (path c, table 4). Socioeconomic circumstances have been modelled comprehensively in this paper as it is probable that different measures of socioeconomic circumstances have a synergistic effect on cognitive function.26–28 The persistence of the association between leisure activities and cognition could be interpreted in two ways:

Engagement in complex leisure augments cognitive function: this interpretation of our results is supported by research on neuronal plasticity in adults,29 older people,30 and patients with dementia.31 However, research on plasticity focuses on acquisition of specific skills as a result of specific training. The research linking high occupational attainment and cognitive function in adult life suggests that the stimulation provided by work helps to maintain cognitive function.32–34 It is possible that mental stimulation provided by complex leisure activities has a similar effect. Our results need to be
### Table 4  Sociodemographic variables, leisure activities/hobbies, and cognitive function

<table>
<thead>
<tr>
<th>Effect</th>
<th>Memory</th>
<th>AH 4</th>
<th>Mill Hill</th>
<th>Phonemic fluency</th>
<th>Semantic fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path a: (Effect of age on SES)</td>
<td>-0.26</td>
<td>-0.22</td>
<td>-0.22</td>
<td>-0.22</td>
<td>-0.22</td>
</tr>
<tr>
<td>Path b: (Effect of age on low effort activities)</td>
<td>0.12</td>
<td>0.15</td>
<td>0.18</td>
<td>0.21</td>
<td>0.20</td>
</tr>
<tr>
<td>Path c: (Effect of age on high effort activities)</td>
<td>0.16</td>
<td>0.16</td>
<td>0.14</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Path d: (Effect of age on social activities)</td>
<td>0.11</td>
<td>0.13</td>
<td>0.13</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>Path e: (Effect of SES on cognitive function)</td>
<td>0.18</td>
<td>0.18</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Path f: (Effect of SES on low effort activities)</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
</tr>
<tr>
<td>Path g: (Effect of SES on high effort activities)</td>
<td>0.33</td>
<td>0.33</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>Path h: (Effect of SES on social activities)</td>
<td>0.31</td>
<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
<td>0.32</td>
</tr>
<tr>
<td>Path i: (Effect of high effort activities on cognition)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Path j: (Effect of high effort activities on cognitive function)</td>
<td>0.09</td>
<td>0.14</td>
<td>0.06</td>
<td>0.17</td>
<td>0.08</td>
</tr>
<tr>
<td>Path k: (Effect of high effort activities on social activities)</td>
<td>0.06</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*Significant sex differences are in bold.

**Key points**

- Regular participation in leisure activities has a positive association with cognitive function.
- Activities high on social engagement are more strongly related to cognition than those engaged in low effort activities.
- Leisure activities high in cognitive effort have a stronger relative impact on cognition in middle age.

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*Effect represented as $\beta$, standardised regression coefficient, and effects significant at $p<0.001$ unless equal to zero. Fit measures for all five models was the same, RMSEA = 0.08, CFI = 0.99. Significant sex differences are in bold. First set of estimates in the rows are from models that classify leisure as requiring high or low cognitive effort, second set from leisure classes as individual or social.
not engage in leisure activities making this issue particularly relevant to the low SES, older people who do not engage in leisure activities.

There are some obvious caveats to the conclusions drawn in this study. The results are cross sectional and need to be replicated in a longitudinal study before causal relations can be presumed. Furthermore, results obtained here need to be interpreted in light of the fact that Whitehall II is a study of white collar workers and does not represent the whole socioeconomic range. Our results suggest that participation in leisure is socially patterned, whether leisure activities has the same impact in a more heterogeneous population remains to be investigated.

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