Where Did I Leave My Keys? A Twin Study of Self-Reported Memory Ratings Using the Multifactorial Memory Questionnaire

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Behavior genetics has convincingly shown the importance of genetic factors in objective tests of memory function. However, self-report memory tests have received little attention. This study used items from the Multifactorial Memory Questionnaire (MMQ) to estimate the heritability of self-reported memory contentment and ability in 909 monozygotic (MZ) and 1034 dizygotic (DZ) twin pairs aged between 20 and 84 years from the St Thomas' Adult UK Twin Register. Heritability estimates ranged between 37% and 64% for contentment (e.g., reporting to worry about one's memory) and approximately 45% for ability (e.g., reporting a tendency to forget keys). Shared family environmental influences (between 32% and 33%) were found for some abilities (e.g., learning to use a new gadget). Given their clinical significance and ease of administration, these tests could prove to be useful in examining memory functioning in large-scale population studies.

The extent to which genetic or environmental factors influence memory is of great interest to behavioral psychologists as well as researchers studying the pathology of memory and memory loss. Geneticists have focused on objective memory tasks (e.g., recalling a series of numbers or memorizing various pictures) in formally appraising the genetic basis of memory. There are many such measures of memory available and heritability estimates vary from 30% to 60% (Thapar et al., 1994). However, the practical relevance of these tests to an individual's experience of their memory function is not clear. For example, it is uncertain how objective findings relate to everyday experiences of memory failure such as losing ones keys.

There are several self-report memory questionnaires available for use with research participants and brain-injured clinical patients. The Multifactorial Memory Questionnaire (MMQ; Troyer & Rich, 2002) contains 57 items that address memory issues and changes relevant to healthy ageing. Good psychometric data have been presented for the factor structure, reliability and validity of this test (Troyer & Rich, 2002).

Although items from these questionnaires correlate only weakly with objective tests of memory (Little et al., 1986; Rabbitt & Abson, 1990), they do have substantial face validity with respect to practical memory function and have been shown to be of direct clinical relevance. For example, subjects with documented poor memory abilities demonstrate low scores on the MMQ (Troyer & Rich, 2002). A number of risk factors have been identified as influencing self-report measures of memory function including age, sex, education and health factors, but their contribution is relatively small (Cutler & Grams, 1988). Self-reported memory has not, to our knowledge, been subjected to quantitative genetic analysis and the relative contribution of genetic factors is unknown. In this study, we report the heritability of items of memory contentment and memory ability, taken from the MMQ, using a classical twin design.

Methods

Participants

St Thomas' Adult UK Twin Register (Spector & MacGregor, 2002) is a large database of over 5000 twin pairs, consisting of predominantly Caucasian females. They were originally recruited through a national media campaign and from twin registers (Spector et al., 1996).

The zygosity of the twins was assessed by questionnaire, which has an accuracy of over 95% (Martin & Martin, 1975) and validated by multiplex DNA fingerprinting using variable tandem repeats where necessary, thus giving 99.7% accuracy. This is a volunteer sample that is representative of the United Kingdom population (Andrew et al., 2001). All are

healthy volunteers with no known cognitive or neuropsychological deficits.

Questionnaire Measures

A self-completion questionnaire was posted to the twins who completed their answers separately and without knowledge of their co-twin's responses. The memory questions were included as part of a wider assessment that included questions relating to general health so the twins were unaware of the specific hypothesis being examined.

The items included in the questionnaire were selected from the MMQ (Troyer & Rich, 2002). The original MMQ is 57 items long and would have been difficult to complete fully as part of a larger questionnaire. The following items were selected:

Contentment

1. How do you rate your memory?
2. Is your memory worse than this time last year?
3. Do you worry about your memory?

Ability
Do you have difficulty:

1. remembering where you put your glasses or keys?
2. remembering what clothes you wore yesterday?
3. learning how to use a new gadget or machine around the house?
4. remembering what day and month it is?

Twins were asked to respond *good*, *fair* or *poor* to MMQ-contentment item 1 and *yes* or *no* to each of the remaining items. The frequency of those responding *poor* to MMQ-contentment item 1 was low and this item was consequently made into a dichotomous trait (*good* vs. *fair/poor*).

Test–retest reliability for both the MMQ-contentment and MMQ-ability has been shown to be high ($r = .93$, $p < .001$ and $r = .86$, $p <.001$, respectively). Internal consistency is also strong — Cronbach's alpha is high for both MMQ-contentment ($\alpha = .95$) and MMQ-ability ($\alpha = .93$). Construct validity tests have shown good correlations with other self-report memory questionnaires. The relation between MMQ-ability and objective memory tasks is weak but those with good memory function (no more than 2 *SD*s from the mean on a word-list task) were found to score higher on the scale than those with a low-memory function (Troyer & Rich, 2002).

Modeling

Monozygotic (MZ) twins share the same genes while dizygotic (DZ) twins share on average 50% of their segregating genes. If both classes of twin are assumed to share their family environment to the same extent (Kyvik, 1999), any greater similarity between MZ than DZ twins can be attributed to genetic influences. Contrasting concordance among MZ and DZ twin pairs allows the relative contribution of genetic and shared environmental influence to be estimated and

quantified. Here, we estimate casewise concordance: the probability that a twin is affected given the co-twin is affected (calculated by the formula $2c/(2c + d)$ where c is the number of concordant cases and d is the number of discordant cases).

The variables included in the present analysis were dichotomous. The analysis was conducted for each variable separately by using a logistic implementation of the DeFries Fulker regression method (Sham et al., 1994). In this approach, a set of models were examined that included: additive genetic variance, A (additive effects of alleles at each contributing locus); the shared environmental variance, C (environmental events common to both members of a twin pair); and unique environmental variance, E (environmental effects not shared by both members of a twin pair). Thus the significance of the variance components A and C is assessed by removing each in submodels and testing the deterioration in fit compared with the full model. The details of fitting models to data on twins have been described elsewhere (Neale & Cardon, 1992).

Results

The questionnaire was completed by 3886 female twins comprising 909 MZ and 1034 DZ pairs. The mean age of respondents was 52.6 years ($SD = 12.8$) and ranged from 20 years to 84 years. Typical of an ageing population, it was found that those who report a fair or poor memory with memory difficulties are significantly older (54.0 years) than those who report a good memory with no other memory difficulties (51.2 years, $t = -6.6$, $p < .001$). There were no significant differences between the zygosity groups.

Casewise concordance and the results of model fitting are shown in Table 1 and Table 2, respectively. We found that 37% to 64% of the total variance between individuals' ratings on MMQ-contentment was due to additive genetic factors. There was no evidence to suggest a contribution from the shared environment. A heritability of 64% (confidence intervals [CIs] 55% to 73%) was found for 'How do you rate your memory?', with the other items 'Is your memory worse than this time last year?' and 'Do you worry about your memory?' exhibiting heritabilities of 37% (CIs 27% to 47%) and 46% (CIs 36% to 56%), respectively.

MMQ-ability questions showed substantial variation in the contribution of both genes and the shared environment. Shared family environmental factors were involved to explain variation in remembering clothes worn (32%) and ability to learn using a new gadget (33%). In contrast, difficulty remembering where one left one's glasses or keys and recalling the current date showed no evidence of a shared environmental effect, with genetic factors contributing to the association in responses seen in the twins. A heritability of 45% (CIs 35% to 54%) was found for difficulty recalling the location of glasses or keys and difficulty remembering the day and the month had a heritability of 36% (CIs 23% to 50%).

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Table 1

Concordance Table

	MZ			DZ		
	Concordant (+ +) (N pairs)	Discordant (+ −) (N pairs)	Casewise concordance % (95% CI)	Concordant (+ +) (N pairs)	Discordant (+ −) (N pairs)	Casewise concordance % (95% CI)
Contentment						
1. Rate memory (good vs fair/ poor)	323	257	71.5 (68, 75)	261	422	55.3 (51, 59)
2. Worse than last year (yes, no)	90	259	41.0 (35, 47)	90	360	33.3 (28, 38)
3. Worry about memory (yes, no)	113	252	47.3 (42, 53)	129	335	43.5 (39, 48)
Ability: forget						
1. Keys (yes, no)	162	283	53.4 (49, 58)	149	411	42.0 (37, 47)
2. Clothes (yes, no)	6	74	14.0 (4, 24)	9	90	16.7 (7, 26)
3. Gadget (yes, no)	81	248	39.5 (34, 46)	76	290	34.4 (29, 40)
4. Day (yes, no)	23	135	25.4 (17, 34)	20	192	17.2 (11, 24)

Discussion

In this study of 3886 female twins, a substantial heritable component for memory contentment and some aspects of ability has been shown, according to an individual's subjective assessment.

Although MMQ-contentment items showed a uniform genetic effect, MMQ-ability items presented differing results with some items (2 and 3) being influenced to a certain degree by the shared family environment, whereas others were more likely to be influenced by genetic factors (1 and 4). Although certain learned techniques may be employed to help remember where one puts things (e.g., leaving them in a particular place or retracing one's steps), it would appear forgetfulness for objects is linked to specific memory processes, a proportion of which we inherit. Whether a storage or retrieval failure, it is certain that genetic influences operate here. Indeed, several genes (CREB, COMT, BDNF and APOE) have been identified that are believed to influence both long- and

Table 2

Model-Fit Statistics

	Model	A (95% CI)	C (95% CI)	Difference in χ^2	p value
Contentment					
1. Rate memory (good vs. fair/ poor)	ACE	0.85 (0.57, 1.13)	−0.17 (−0.38, −0.04)	—	—
	CE	—	0.45 (0.38, 0.51)	71.3	< .001*
	AE	**0.64 (0.55, 0.73)**	**—**	**2.55**	**.11***
2. Worse than last year (yes, no)	ACE	0.43 (0.12, 0.75)	−0.05 (−0.29, 0.19)	—	—
	CE	—	0.26 (0.19, 0.34)	14.5	< .001*
	AE	**0.37 (0.27, 0.47)**	**—**	**0.33**	**.57***
3. Worry about memory (yes, no)	ACE	0.33 (0.03, 0.63)	0.11 (−0.12, 0.34)	—	—
	CE	—	0.35 (0.27, 0.42)	9.45	< .001*
	AE	**0.46 (0.36, 0.56)**	**—**	**2.32**	**.13***
Ability: forget					
1. Keys (yes, no)	ACE	0.60 (0.30, 0.89)	−0.12 (−0.35, 0.10)	—	—
	CE	—	0.31 (0.24, 0.39)	32.0	< .001*
	AE	**0.45 (0.35, 0.54)**	**—**	**2.22**	**.14***
2. Clothes (yes, no)	ACE	−0.06 (−0.64, 0.52)	0.37 (−0.07, 0.80)	—	—
	CE	**—**	**0.32 (0.20, 0.57)**	**0.09**	**.77***
	AE	0.39 (0.20, 0.57)	—	5.19	.02*
3. Gadget (yes, no)	ACE	0.16 (−0.16, 0.49)	0.21 (−0.05, 0.46)	—	—
	CE	**—**	**0.33 (0.25, 0.41)**	**1.97**	**.16***
	AE	0.41 (0.31, 0.52)	—	5.05	.02*
4. Day (yes, no)	ACE	0.43 (0.00, 0.87)	−0.06 (−0.40, 0.28)	—	—
	CE	—	0.26 (0.15, 0.37)	7.84	< .001*
	AE	**0.36 (0.23, 0.50)**	**—**	**0.23**	**.63***

Note: A = additive genetic; C = common environment; E= unique environment. *Compared with ACE model. The best-fitting model is highlighted.

short-term memory functions (see Alberini, 1999, or Nilsson et al., 2002, for a review).

Mastering a new gadget or recalling clothes worn, on the other hand, showed no evidence of genetic influences. The extent to which the genetic contribution varies between phenotypes is interesting because these are all phenotypes that show strong phenotypic correlation with each other. It is likely, therefore, that any genetic structure that underpins these self-reported memory measures will prove to be complex and merit further study.

Our findings are consistent with observations that heritable influences are of importance in determining responses to objective memory tasks. In several recent studies (Ando et al., 2001; Finkel & McGue, 1998; Finkel et al., 1995; Johansson et al., 1999; Thapar et al., 1994), genetic influences have been shown to influence digit span tasks and picture memory tasks for example (Johansson et al., 1999; Pedersen et al., 1992; Thapar et al., 1994), with heritability estimates ranging from 30% to 60%.

Objective tests of memory have predictive clinical value and many neuropsychological tools exist (e.g., Estevez-Gonzalez et al., 2003; Mathuranath et al., 2000; Sahakian & Owen, 1992). However, their relevance to the practical assessment of memory problems is questionable (Troyer & Rich, 2002). In contrast, subjective tests of memory have an obvious application to the common problems of everyday life. Furthermore, they have clinical significance in organic brain disease. For example, in Alzheimer's Disease it has been shown that elderly subjects with subjective memory complaints exhibit significantly greater decline in memory and cognition than those with no complaints (Schofield et al., 1997). In one study of 2537 nondepressed and nondemented individuals, questions about the presence or absence of memory complaints and memory-related problems in daily functioning were found to be predictive of subsequent memory impairment (Jonker et al., 1996). Memory complaints may also predict dementia (reviewed in Jonker et al., 2000).

In interpreting the results of studies of subjective memory, it should be appreciated that additional factors are likely to have a bearing on memory reporting that may only be indirectly related to pure memory function. There is reliance on recall and greater variability perhaps due to an individual's expectation and/or the social context (Derouesne et al., 1999; Jonker et al., 2000). The variability found in the genetic contribution to some of the MMQ-ability questions may be a reflection of this. Contentment or satisfaction with one's memory is also likely to be mediated by anxiety, depression and personality factors. Indeed, relationships have been established between MMQ-contentment and scales of anxiety and depression (Troyer & Rich, 2002). Genetic influences for these factors have also been demonstrated (Rijsdijk et al., 2003). Accounting for such variables was beyond the scope of the present study.

Finally, it has been noted that subjective testing, though offering a valuable insight into behavior, does not always reflect absolute levels of everyday competence (Little et al., 1986; Rabbitt & Abson, 1990) and as a predictor of dementia, some studies find objective testing to be a more powerful tool (Flicker et al., 1993). Thus, if the genetic architecture of memory is to be fully elaborated it seems clear that future studies would need to combine subjective and objective tests with a range of psychosocial and behavioral variables.

Technology now exists to map genes in great detail yet success in finding genes is still very much dependent on adequate definition of the phenotype. The present study suggests that simple questions may capture clinically relevant variables for use in large sample studies where individual testing is not possible. There is potential for such studies of heritability to help in the search for genes in one of our more complex of complex traits. Losing one's keys could well unlock the door to genes for memory.

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