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REACTION TIMES MEASURED IN A CHOICE REACTION TIME AND A DOUBLE TASK CONDITION: A SMALL TWIN STUDY

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Summary—A genetic analysis of simple reaction times (RT) measured in young twins is reported. Reaction times were obtained in a choice RT task with varying interstimulus intervals and in a mixed task condition that consisted of the same choice RT trials and of double task trials, where subjects simultaneously performed mental arithmetic and the choice RT task. All RT measures showed significant influence of common environment. Heritabilities were task dependent: for the choice RT task higher heritabilities were seen for shorter (2 and 3 sec) than for longer (4 and 5 sec) interstimulus intervals. In the mixed condition heritabilities of almost 50% were seen for RT measured in double task trials, whereas no genetic influence was observed for choice RT trials (3 and 5 sec interstimulus interval) in this condition.

INTRODUCTION

Two earlier twin studies of reaction times (RT) assessed in complex processing tasks obtained relatively high heritabilities for general speed factors. McGue and Bouchard (1989) observed heritabilities of 0.54 and 0.58 for basic and spatial speed factors in a sample of MZ and DZ twins reared apart. An acquisition speed measure showed no significant genetic effects. Vernon (1989) using twins reared together found a similar heritability of 0.49 for a general speed factor based on eight different complex RT tests. The pattern of MZ and DZ correlations in this study also suggested some influence of common environment. Vernon hypothesized that RT tests that require more complex mental operations show higher heritabilities. In his own research he found a correlation of 0.676 between heritability and complexity of the task. Based on Vernon's hypothesis it would seem interesting to study RT obtained in tasks that do not require mental operations. In this paper we report heritabilities for simple RT measures. These were obtained in a choice RT task with varying interstimulus intervals and in a mixed task condition. In the mixed condition choice RT trials were presented together with double task trials, where *S*s simultaneously performed mental arithmetic and the choice RT task. According to Vernon we expect to find low heritabilities in the choice RT task and higher heritabilities for double task trials.

METHODS

Subjects

Twenty-four twin pairs betwen 15 and 18 years participated in the study. Zygosity was determined by blood group polymorphisms. There were 12 MZ and 12 DZ pairs with 6 male and 6 female pairs within each zygosity. Twins were paid a fixed sum for the participation and a small bonus for each correct answer in the mental arithmetic task.

Tasks and procedure

Twins came to the laboratory in pairs and were tested under two conditions: a choice RT task with interstimulus intervals (ISI) of different length and a mixed condition that consisted of single mental arithmetic (MA) trials, single choice RT trials and trials in which the MA and RT tasks had to be performed simultaneously. In the choice RT condition there were four ISI lengths: 2, 3, 4 and 5 sec. Each ISI was presented 20 times. In the mixed condition there were five different

trials: single RT with ISI length 3 or 5 sec; single MA in which *S*s were given four numbers at fixed time points and after 7 sec had to give an answer and combined MA + RT trials. In the MA + RT trials *S*s also had to add four numbers in 7 sec. In addition a reaction signal was presented after 3 or 5 sec. All trials were replicated 16 times. In both conditions 20 randomized trials were presented in four blocks. Each block started with four warming-up trials that were omitted from later analyses. Order of the two conditions was counterbalanced across twin pairs. Before the actual experiment started *S*s received at least 25 practice trials for each condition.

Apparatus

Each trial started with the simultaneous onset of a warning signal consisting of colored lights and a number on a three-digit display. The reaction signal was a tone of 80 dBA and 1000 or 3000 Hz that lasted 500 msec. *S*s reacted by pushing a button with their right hand to the high tones and with their left hand to the low tones or vice versa (counterbalanced across pairs). Reaction times were measured in msec. In the choice RT condition the warning signal consisted of a red light and a number on the display indicating ISI duration. In the mixed condition the color of the light indicated ISI length (red 3 sec, yellow 5 sec) and the display was used to present four numbers that had to be added together. For the single RT trials the number zero was shown. Onset of single MA trials was characterized by a red plus a yellow light. *S*s were seated in a sound attenuated room and wore padded ear phones. During the experiment heart rate was measured, these results have been published elsewhere (Somsen, Boomsma, Orlebeke & van der Molen, 1985; Somsen, van der Molen, Boomsma & Orlebeke, 1985).

RESULTS

Descriptive statistics

Mean RT and standard deviations for the different trials in the two task conditions are given in Table 1. Trials with incorrect RT responses were omitted from the analysis. Trials in the mixed condition with addition errors (wrong solutions to the MA problem) were included if the *S*s had pushed the correct button. ANOVA with ISI(4) and twin1/twin2(2) as repeated measures showed for the choice RT condition a significant decrease in RT as ISI increased ($F3,69 = 3.12$, $P = 0.05$; all significance tests for within *S*s variables Greenhouse & Geisser corrected). The average number of errors for the choice RT condition was 3.5 (no difference between ISIs). For the mixed condition, there was a highly significant trial effect, both for mean RT ($F3,66 = 3133.6$, $P < 0.00$) and for a number of errors made ($F3,66 = 14.38$, $P < 0.00$). Reaction times were much longer when *S*s performed the double task of addition and reacting to the tones. The numbers of RT errors was also larger in the double task situation (3.6 and 4.5 for the double task, 2.3 and 2.0 for single RT trials). In the choice RT task intercorrelations between reaction times from different ISIs were 0.9 or higher, both for twin1 and twin2. In the mixed condition correlations among the same kind of trials (i.e. single RT or MA + RT trials) were 0.8 or higher, correlations between single RT and MA + RT trials were 0.6 on average.

Genetic analyses

Table 2 shows intraclass correlations and univariate model fitting results for both task conditions. In the choice RT condition the pattern of MZ and DZ correlations is quite different for shorter as compared to longer ISIs. The short ISIs are suggestive of strong genetic influence

Table 1. Mean reaction times and SD for the choice RT condition (ISI = 2, 3, 4 or 5 sec) and the mixed condition: MA + RT (ISI = 3 or 5 sec) or single RT trials (ISI = 3 or 5 sec)

Choice RT condition			Mixed RT + MA condition		
ISI	Mean	SD	Task	Mean	SD
RT2	352.38	93.07	MA + RT3	560.23	132.34
RT3	352.12	75.16	MA + RT5	612.39	129.61
RT4	341.24	69.56	RT3	395.67	84.47
RT5	339.60	74.63	RT5	381.35	77.83

Table 2. Univariate analyses: intraclass correlations (t) and model fitting results

	t		ECG model	Reduced models	%
	MZ	DZ	χ^2 and P	χ^2 and P	h or c
			Choice RT Task		
RT2	0.87	0.38	0.38 (0.54)	EG: 0.38 (0.83)	85
RT3	0.87	0.36	3.64 (0.06)	EG: 4.10 (0.13)	80
RT4	0.79	0.71	2.72 (0.10)	EC: 2.72 (0.26)	77
RT5	0.78	0.73	4.21 (0.04)	EC: 4.21 (0.12)	77
			Mixed Reaction Time/Mental Arithmetic Task		
MA + RT3	0.39	0.20	0.85 (0.36)	EG: 0.85 (0.65)	45
MA + RT5	0.52	0.05	1.09 (0.30)	EG: 1.09 (0.58)	48
RT3	0.51	0.41	2.61 (0.11)	EC: 2.62 (0.27)	47
RT5	0.38	0.38	0.88 (0.35)	EC: 0.88 (0.64)	38

on RT while individual differences in the longer ISIs seem mainly influenced by common environment. This is confirmed by the model fitting results. For ISI 2 and 3 sec heritabilities of 80 and 85% are found, for ISI 4 and 5 sec an almost equally large effect (77%) of common environment is seen. A similar kind of result is seen in the mixed condition. The MA + RT trials show heritabilities of 48 and 45%, the single RT trials show common environmental effects of 47 and 38%.

Results of 4-variate analyses for both task conditions are given in Table 3. For both conditions a factor model (Martin & Eaves, 1977), with only a shared unique environmental factor (E) does not provide a good description of the data. Addition of either a shared genetic (G) or common environmental factor (C) gives a clear improvement, while a factor model with three shared factors (E, G and C) still gives a significant reduction in χ^2. In the final ECG factor models most loadings have been constrained to be equal to each other. For the choice RT task, genetic factor loadings for RT2 and RT3 and genetic factor loadings for RT3 and RT4 were constrained to be equal. Loadings on the E and C factors were equal for all four ISIs. Variances unique to each variable (U) were equal for RT4 and RT5. The percentages of variance accounted for by each factor in this final model are shown at the bottom of Table 3. The familial aggregation and the high within-person correlations are accounted for by high loadings on the common environmental factor and heritabilities are relatively low. In the mixed condition, factor loadings and unique variances for the double task trials and factor loadings and variances for the simple RT trials were constrained to be equal. Here the double task trials show heritabilities of 48% and no genetic influence on simple RT trials is present.

Table 3. Multivariate analyses for choice RT and mixed task

			Choice RT		Mixed task	
	Factors	df	χ^2	P	χ^2	P
	χ^2 and probability level for different factor models					
	E	32	70.39	0.000	53.71	0.009
	EG	28	42.37	0.040	33.50	0.218
	EC	28	43.62	0.030	33.70	0.211
	ECG	24	36.38	0.050	25.12	0.399

	Choice RT					Mixed Task			
	G	C	E	U		G	C	E	U
	Constrained ECG Models: Parameter Estimates								
RT2	37.6	62.6	27.8	1616.7	MA + RT3	98.1	58.9	66.7	2537.6
RT3	37.6	62.6	27.8	136.2	MA + RT5	98.1	58.9	66.7	2537.6
RT4	18.8	62.6	27.8	412.9	RT3	—	55.4	45.8	1682.2
RT5	18.8	62.6	27.8	412.9	RT5	—	55.4	45.8	1682.2
$\chi^2 = 47.21$, $df = 33$ ($P = 0.052$)					$\chi^2 = 32.90$, $df = 33$ ($P = 0.472$)				
	Constrained ECG Models: % of Variance								
RT2	18	51	10	21	MA + RT3	48	17	22	13
RT3	23	63	12	2	MA + RT5	48	17	22	13
RT4	7	72	13	8	RT3	—	45	30	25
RT5	7	72	13	8	RT5	—	45	30	25

G(enetic), E(nvironment) and C(ommon environment) are factors, U is variance unique to each variable (including measurement error). Factor loadings and variances are estimated by maximum likelihood.

DISCUSSION

The heritabilities found in this study for simple RT measures are indeed lower than the ones reported by Vernon (1989) and by McGue and Bouchard (1989). The familial aggregation for RT is mainly accounted for by common environmental influences. But the pattern of genetic influences on RT is also situation dependent: RT3 measured in the choice RT condition shows a heritability of 23%, whereas RT3 measured in the mixed task condition shows no genetic influence. There is a strong suggestion that within each task condition heritabilities are higher if the trials are more stressful. In the choice RT condition the shorter ISIs are more stressful as indicated by longer mean RTs. In the mixed condition the double task trials are clearly the most stressful and here the highest heritabilities are seen. Of course, these results are based on a small sample and it would also seem that these conclusions are based on rather different results from the uni- and multivariate analyses. Multivariate analyses are considerably more powerful, however, than univariate ones, especially if the latent factors have more than one reliable indicator (Matsueda & Bielby, 1986). Our general conclusion thus is based on the results from the multivariate analyses.

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