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What Virtual Twins Reveal About General Intelligence and Other Behaviors

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Abstract

The Fullerton Virtual Twin Study has been assessing the behaviors of an unusual sibship since 1982. Virtual twins (VTs) are same-age, unrelated siblings reared together since infancy. They replicate the rearing situation of twins but without the genetic link, enabling direct assessment of shared environmental effects on behavior. An updated analysis of IQ data, based on an increased sample of 142 VT pairs (7.87 years, $SD=8.22$), is presented. Intraclass correlations of .28 (IQ) and .11 (subtest profile) indicated modest shared environmental influences on intelligence. Findings from the Twins, Adoptees, Peers and Siblings (TAPS) project that studies virtual twins and other kinships are described.

1. Introduction

Virtual twins (VTs) are same-age, unrelated siblings reared together since infancy. They replicate the rearing situation of twins, but without the genetic link, enabling direct assessment of shared environmental effects on behavioral and physical traits. Most VT pairs include two adopted children, or one adoptee and one biological child of the rearing parents. The research advantages of VTs, compared with ordinary adoptive siblings, are that members of VT pairs share their age, residential histories and many life experiences. An updated VT analysis of IQ data from the Fullerton Virtual Twin Study is presented, followed by findings from the TAPS (Twins, Adoptees, Peers and Siblings) project. This work illustrates the usefulness of including VTs in psychological research.

1.1. Virtual Twins and IQ

A 2005 report found little VT similarity in general intelligence ($r_t=.26$, $n=113$ pairs), suggesting modest shared environmental influences (Segal & Hershberger, 2005). This result was expected, given previous twin and adoption studies indicating genetic and non-shared environmental effects on general ability. Results from a study using a larger VT sample concurred with these findings (Segal, 2010). In related work, the IQ intraclass correlation for a VT subsample ($n=43$ pairs) tested twice decreased from .30 (age 5.11

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years) to .11 (age 10.77 years), demonstrating the waning of shared environmental influences and the increasing effects of other sources of influence on intelligence during development (Segal, McGuire, Miller & Havlena, 2008).

2. Materials and Methods

2.1 Participants

Virtual twins must meet specified guidelines:

Adoptees must be in their homes by age one year.

Sibling age differences must be less than nine months.

Siblings must attend the same school grade.

Participants must be free of adverse birth events

Participants must be minimally four years of age.

Same-sex and opposite-sex siblings are accepted into the study because DZ twins may be same-sex or opposite-sex. Siblings of different ethnicities also qualify because DZ twins with interracial parents may appear different physically (Segal, 2000a).

Virtual twins occur most commonly when couples adopt two near-in-age infants almost simultaneously, as shown in Table 1. However, a substantial minority of VT pairs result when mothers conceive children while seeking adoption. The present study included several pairs created in other ways, as explained later.

Participants' mean age was 7.87 years ($SD=8.22$) and the mean age difference was 3.22 months ($SD=2.77$). The mean ages of mothers and fathers were 43.24 years ($SD=7.20$) and 45.72 years (9.66), respectively. Most mothers (60%) and fathers (78%) were engaged in professional-level occupations. (Ages were missing for 3 mothers and 22 fathers, and occupational data were missing for 10 fathers.) Older age and higher occupational status are characteristic of adoptive parents who often delay child-bearing and undergo prescreening by social workers. Additional sample characteristics are shown in Table 2.

2.2 Materials

Virtual twins were located throughout the United States and Canada. Most pairs (85%) were identified through newspaper or magazine articles, and personal referrals. The remainder was located via television, radio, self-referral and other sources. Families received materials by mail, (among them an informed consent letter, family demographic questionnaire, Child Behavior Checklist, Adjective Checklist, medical/dental history and personality checklist) to complete and return to the laboratory. Children also completed the Wechsler IQ test, administered by testers recruited in the cities where families resided. With only a few exceptions, pair members were tested by different examiners to avoid biased administration and scoring, and were tested on the same day to prevent discussion of items. Test protocols were reviewed for scoring accuracy upon receipt. Additional discussion of procedures is provided in Segal (1997, 2000b).

3. Results

3.1 Mean IQ Scores

The VTs' mean IQ score, shown in Table 3, was 105.83 (SD=13.37), somewhat above the average IQ score of 100 and with slightly smaller variance, consistent with expectations for a volunteer sample raised in predominantly upper-middle class homes. The intraclass correlation of .28, an index of shared environmental influence, replicated findings from previous analyses of smaller VT samples (.21 to .26). The mean IQ difference of 12.71 (SD=9.76) was somewhat less than the 14-point difference for full siblings and the 17-point difference expected for unrelated individuals selected randomly (Plomin & DeFries, 1980); twins and non-twins on which these data are based ranged from age three to the mid-twenties. This is most likely due to the more salient effects of family environments on behavior when children are young. Support for this interpretation comes from adoption studies documenting increasing IQ dissimilarity between unrelated siblings approaching adolescence (Scarr, Weinberg & Waldman, 1993). Recall from section 1.1 that a subsample of 43 VT pairs tested twice declined in IQ resemblance between five and ten years of age (Segal et al., 2007).

3.2 Correlations Between IQ and Other Measures

Age at testing correlated modestly, but significantly, with IQ (.24, $p < .01$), Verbal IQ (.19, $p < .01$) and Performance IQ scores (.24, $p < .01$), showing that older children outperformed younger children. This might reflect the greater IQ stability of children above age seven. Pair type (biological-adopted or adopted-adopted) also correlated positively with IQ (.22, $p < .01$), Verbal IQ (.17, $p < .01$) and Performance IQ (.22, $p < .01$), with members of biological-adoptive pairs outscoring members of adopted-adopted pairs. This result may reflect the transmission of both genes and environments conducive to high intelligence by the generally professional-level biological parents to their biological children. Adopted children in these homes would have also been likely to benefit from the enriched environment. Age at entry into the family (full sample) and age at adoption (225 adoptees) showed modest negative, but significant correlations with IQ and Verbal IQ (–.15 to –.18, $p < .01$), indicating that earlier arrival in the home predicted better performance. This most likely reflected the better health of infants before being released to their biological or adoptive families.

3.3 IQ Differences and Pair Characteristics

Mean pair age correlated modestly, but significantly, with intrapair differences in IQ (.23, $p < .01$) and Verbal IQ (.24, $p < .01$), but not Performance IQ. Specifically, differences were larger for older pairs than younger pairs. IQ differences were not associated with age difference, difference in age at testing, test interval, pair sex (same or different), pair type (adopted-biological/adopted-adopted) or ethnicity (same/different). However, the intrapair Verbal IQ difference correlated significantly with attending the same class (.27, $p < .01$) and with the percentage of years that siblings attended the same class (–.25, $p < .01$). Common classroom placement was associated with a smaller Verbal IQ difference, but the causal relationship between these measures was uncertain.

3.4 IQ Profile Correlations

A concordance estimate for the VTs' IQ subtest profiles was calculated using a two-factor mixed design with repeated-measures on one factor, adapted for twin research (Wilson, 1979). Findings from an earlier twin study provided comparative data (Segal, 1985). Profile correlations and 95% confidence intervals for the three sibships were MZ: .45 (.24 – .62), DZ: .24 (–.09 – .53) and VT: .11 (–0.6 – .27) and all were statistically significant. The MZ

twin profile correlation significantly exceeded the DZ twin profile correlation ($z=3.37$, $p<.001$), and the VT profile correlation ($z=6.17$, $p<.001$); the DZ correlation exceeded the VT correlation, but the difference was not significant. In addition, the percentages of variance associated with pair concordance in the profile correlations corresponded with the pairs' degree of biological relatedness (MZ: 34%, DZ: 13%, VT: 6%). The twin correlations were based on ten subtests, while the VT correlations were based on six, due to updated Wechsler test versions administered to the VTs who were assessed later. However, this should not have affected the pattern of findings because comparable results were obtained previously using a larger subtest array (Segal & Hershberger, 2005).

3.5 Biological vs. Adopted Siblings

The higher IQ scores of the members of adopted-biological VT pairs deserved further examination. First, the full VT sample was organized into biological offspring and adoptees and the mean scores compared. The mean IQ score of the biological siblings significantly exceeded that of the adoptive siblings, shown in Table 4. This result was replicated by examining the paired data for the members of the 49 adopted-biological pairs [$t(48)=4.09$, $p<.001$]. Biological children scored 113.08 ($SD=14.64$), whereas adoptive children scored 105.67 ($SD=12.53$). The signed mean difference was 7.41 ($SD=12.66$).

A related analysis concerned the IQ similarity of the adopted-biological vs. adopted-adopted VT pairs. Biological parents transmit both genes and environments to their children, which can result in passive gene-environment (GE) correlation, alluded to earlier. In biological-adoptive pairs, the genotype of the biological child correlates with the environment of the adoptive sibling, predicting greater resemblance among adopted-biological pairs than adopted-adopted pairs (Loehlin, 1978; Bouchard & McGue, 1981). Horn, Loehlin, & Willerman (1979) observed this pattern for Performance IQ in the Texas Adoption Study (adopted-biological pairs: $r_i=.24$; adopted-adopted pairs: $r_i=.02$). The environmental stimulation from a high-IQ biological child may also enhance adopted siblings' IQs. This pattern was also suggested previously for the IQ and Performance IQ scores of the VTs (Segal & Hershberger, 2005), and was revisited using the present sample of VTs.

The greater adopted-biological than adopted-adopted VT pair similarity was anticipated, but the magnitude of the difference exceeded expectation, as shown in Table 5. In fact, the IQ correlation of the adopted-biological pairs (.47, $p<.001$) approached that of DZ twins (.46) reported by Segal (1985) and full siblings (.47) reported by Bouchard & McGue (1981), a pattern that was repeated for the Verbal and Performance IQ scores.

4. Discussion

The generally observed modest influence of the shared family environment on general intelligence was demonstrated by the present study of 142 virtual twin pairs. The .28 IQ intraclass correlation, while statistically significant, was substantially below the .77, .86, .60 and .50 correlations reported for MZ twins reared apart, MZ and DZ twins reared together, and non-twin siblings, respectively (Segal, in press). Thus, contributions from other sources, such as genetic and non-shared environmental factors to IQ scores were indicated. Consistent with other studies, it is anticipated that the shared environmental influences indicated here will most likely wane as the siblings approach adolescence.

The mean VT intrapair IQ difference of 12.71 points exceeded the mean MZ (6 points) and DZ intrapair (10 points) differences from other studies. The VT difference approached that shown by full siblings (14 points), but was below that of unrelated individuals identified at random (17 points). This is most likely due to the VT participants' young age, given that IQ dissimilarity increases among adolescent adoptive siblings. The magnitude of the within-pair

IQ difference was confirmed by the pattern of findings for the Verbal and Performance IQ scores and IQ profile correlations.

The significantly higher IQ scores of the biological children relative to the adopted children, in general, and to their adopted siblings, in particular, are noteworthy. This finding is consistent with those of other adoption studies (Scarr et al., 1993; Cardon, 1994). Recall that the majority of parents in the present study were pursuing professional/managerial occupations that probably demanded considerable intellectual skill. It is likely that their biological children inherited genetic factors facilitating their development of high ability levels. In contrast, the adoptive siblings may have come from more intellectually heterogeneous biological families. The mean IQ score of adoptees in adopted-biological pairs (105.56, SD=12.64) only slightly exceeded that of adoptees in adopted-adopted pairs (103.74, SD=12.38).

Greater similarity of the adopted-biological pairs, relative to the adopted-adopted pairs was expected, although the observed similarity was somewhat surprising. This finding could have reflected selective placement on the part of adoption agencies (Jencks, 1972), although the biological family data needed to assess this possibility were unavailable and some families sought private adoptions. The somewhat elevated IQ score variance of the biological children, relative to the adopted children, may have partly contributed to these group differences. However, as indicated, the environments of adoptive children in biological-adoptive pairs are correlated with the genotypes of biological children, a factor that was most likely associated with their enhanced similarity, relative to children in adoptive-adoptive pairs. It is unlikely that families with a biological child attempted to match their adopted child's characteristics to their biological child given that both children entered the homes close in time. Furthermore, these couples often sought adoption prior to discovering a natural or assisted pregnancy.

In summary, the modest VT IQ resemblance is consistent with the view that individuals select "niches" reflecting their genetically influenced interests and abilities (Scarr, 1992). However, the effects of family environments on intellectual development cannot be overlooked. Duyme, Dumaret, & Tomkiewicz (1999) found average IQ gains of 7.7 and 19.5 points for children adopted into low SES and high SES adoptive families, respectively. The extent to which these gains persist is unknown, but some early intervention programs like the Carolina Abercadian Project have reported consistent IQ advantages for children enrolled from very early in life, compared with controls. Members of the treatment group maintained their IQ gains through the last assessment age of twenty-one, although both groups declined gradually during childhood and adolescence (Berk, 2009). Continued tracking of adopted-biological VTs will be of interest.

Findings from the present study have implications at theoretical and applied levels. Set within a behavioral-genetic framework, the present study underlines the importance of genetic factors and non-shared environmental contributions to intellectual development. Consistent with other twin and conventional adoption research, the VT study suggests that shared environmental effects influence mental development when children are young and living together, but lose salience as children grow and develop.

The present findings do not imply that parenting and education do not matter. Parents may better understand that their children's objectively similar home experiences may not necessarily affect them in the same way or to the same degree. The fact that near-in-age children sharing a home environment do not show similar intellectual outcomes suggests that other factors, such as their genetic predispositions and unique experiences, explain these outcomes. Teachers can use the findings to more effectively determine children's classroom

placement and to encourage their development of particular talents and skills. They can do this by observing their responses to various educational opportunities provided in the classroom.

Virtual twins offer an informative kinship for disentangling genetic and environmental effects on behavioral development. VTs' closely matched age and time of home entry makes them a more effective comparison group in twin research than ordinary adoptive siblings since they circumvent problems associated with differences in age and placement history. VTs have been incorporated into a variety of behavioral-genetic studies that are summarized below.

5. TAPS: Studies of Twins, Virtual Twins and Other Kinships

Virtual twins have been studied by the Twins, Adoptees, Peers and Siblings (TAPS) project, launched in 2003 (McGuire, Segal, Whitlow, Gill & Clausen, 2010). TAPS is a collaborative effort between researchers at California State University, Fullerton and the University of San Francisco. Several analyses of behavior and health, based on a sample combining twins, virtual twins, siblings and friends, are described in sections 7.1 to 7.5. New ways in which VTs can play a role in behavioral research are explored.

6. Materials and Methods

TAPS uses a biosocial perspective to examine sibling socialization effects in middle childhood, but also assesses factors affecting behavior in many domains. The test battery covers intelligence, social relationships, friendships, parenting and other behaviors, as well as physical traits among seven- to twelve-year-old MZ twins (n=54), DZ twins (n=86), VTs (n=43), full siblings (n=69) and friends (n=48). Child and family data are gathered during a home assessment lasting two to three hours. Analyses have been completed on developmental trends in general intelligence and on body size, tacit coordination, interpersonal trust beliefs, peer network overlap and parenting.

7. Research Summaries

7.1 Body Size

Body mass index (BMI) is a more sensitive index of body size than height or weight alone because it considers the relationship between them. An opportunity to assess genetic and environmental influences on BMI was presented by twin and sibling data from five sources: TAPS, University of Chicago, University of Minnesota, and two CSU Fullerton studies, yielding 929 individuals (Segal, Feng, McGuire, Allison, & Miller (2008).

A linear mixed model estimated the additive genetic, non-additive genetic, shared environmental and unshared random components in BMI. Both non-additive genetic and shared environmental contributions were significant ($p < 0.0001$). A significant additive genetic contribution was not found; instead, 63.6% of the total variance of BMI was explained by a non-additive genetic component, 25.7% by a common environmental component, and 10.7% by an unshared component.

These results suggested that genetic factors play a critical role in BMI, and that shared environmental factors, such as diet and exercise, are also important. This conclusion agreed with a previous study using a smaller twin and VT sample (Segal & Allison, 2002). Most previous twin studies may have underestimated the common environmental components of BMI because they cannot distinguish the non-additive genetic component from shared environmental influences.

7.2 Interpersonal Trust Beliefs

Twins and siblings completed scales based on the Children's Generalized Trust Belief Scale (CGTBS) created by Rotenberg, Fox, Green, Ruderman, Slater, et al. (2005). The new measure presented realistic scenarios to assess trust beliefs regarding individuals' primary caregivers and their siblings. Evolutionary reasoning predicted the following pattern for mean trust scores: $MZ > DZ = FS > VT$.

Data analysis revealed a significant effect of dyad type [$F(3,248)=9.94, p<.001$], with follow-up Tukey tests showing that MZ twins reported significantly higher trust beliefs in their siblings than the other dyads (McGuire et al, 2010). The relative means for these other groups were in the expected directions, but did not differ significantly. Children's trust beliefs in their mother and siblings were significant and positive, consistent with attachment theory positing that children's trust relationships are influenced by relationships with their caregivers. However, evolutionary psychological theories of cooperation that consider interactants' genetic relatedness are better able to explain the differences across dyads.

7.3 Peer Network Overlap

Factors affecting sibling relationships are of interest, as are the implications of sibling relationships for promoting normal or atypical behavioral development. Twins (MZ, DZ), virtual twins (VT), full siblings (FS) and friends (FF) independently listed the names of their friends, indicating those whom they had in common (McGuire & Segal, in press). They were then asked to agree on friends they shared, yielding two measures: total number of friends and total number of shared friends.

The mean number of friends for the full sample was 10.6 ($SD=5.7$), and ranged from 1–33. The mean number of shared friends was 5.6 ($SD=4.5$), and ranged from 0–24. Correlations indicating sibling agreement for shared friends were high and significant across dyad types: MZ: .60, DZ: .73, FS: .76, VT: .81 and FF: .70. Somewhat surprisingly, the VT pairs (who expressed relatively low trust beliefs toward each other) showed the highest agreement regarding how many friends they shared, whereas MZ twins (who expressed the highest trust beliefs) showed the lowest agreement. These findings appear counterintuitive, but are actually reasonable upon closer consideration. VTs high agreement on common friends may reflect a clear separation and recognition of shared and unshared companions. In contrast, MZ twins may share friends to different degrees, so they may be less certain as to those friends who are truly shared and those who are not. Regardless, the percentage of peer overlap was highest for MZ twins (82%) and lowest for opposite-sex full siblings (27%). Same-sex DZ twins (67%) and VTs (62%) showed relatively high agreement, in contrast with opposite-sex DZ twins (42%) and VTs (37%).

Hierarchical regression models identified dyad age, sex composition and genetic relatedness as significant predictors of peer overlap ($p<.001$). This information can potentially help parents and teachers understand the varying levels of social relatedness among siblings and friends. This is important given that previous studies have detected large estimates of shared environmental influences on sibling delinquency (Rowe, 1994).

7.4 Tacit Coordination

Tacit coordination (TC) refers to circumstances in which “two parties have identical interests and face the problem not of reconciling interests but only of coordinating their actions for their mutual benefit when communication is impossible” (Schelling, 1960, p. 54). Tacit coordination may, therefore, be conceptualized as non-negotiated consensus. Genetic influence on TC was assessed using MZ, DZ and VT pairs who participated in TAPS (Segal, McGuire, Miller, & Havlena, 2008). Children independently answered twenty questions

under two conditions: Self in which they simply answered the questions, and Twin in which they answered as though they and their siblings had discussed the questions and reached an agreement. The measures of interest were the matches between co-twins in the two conditions.

The expected pattern of success on this task was obtained under both the Self and Twin conditions: $MZ > DZ > VT$. These results concurred with the behavioral-genetic literature showing that behavioral resemblance varies with the genetic relatedness between family members. The results were also consistent with evolutionary psychological expectations, namely that greater coordination of efforts and goals can be expected between close genetic relatives than between more distant ones.

7.5 Parenting

Early behavioral-genetic studies of parenting revealed heritable components due to passive and reactive (GE) correlations (McGuire, Segal, & Hershberger, in press). Passive GE correlation involves transmission of both genes and environments by parents to children, resulting in similarities between them. Reactive GE correlation involves response to a person as a function of that person's genotype. More recent studies are examining factors mediating genetic and environmental contributions to parenting. Parent and child data from TAPS were used to examine genetic and environmental effects on parental warmth (McGuire, et al., in press)

Parental warmth was assessed among both parents and children using an 8-item scale derived from the "acceptance-rejection" subscale of the Children's Report of Parent Behavior Inventory. Intraclass correlations suggested significant heritable and nonshared environmental influences for child reports and significant genetic and shared environmental influences for parent reports. Model fitting analyses confirmed these indications. The genetic effects in this child-based design reflect the children's genotype, suggesting reactive GE correlation. This would indicate that parenting practices are partly fashioned by children's genetically influences characteristics. However, two children may react differently even when parents display similar levels of warmth to both.

8. Summary

Virtual twins are a valuable addition to behavioral-genetic and evolutionary research when used with MZ and DZ twins and full siblings. Their rarity is assumed, but that is not certain given increased reliance on adoption and assisted reproductive technologies by infertile couples. The Fullerton Virtual Twin Study continues to be contacted by families with VTs, ensuring an expanding sample. However, the VT design is not without concerns. The birth histories of the adoptees are sometimes difficult to verify, such that some VTs who experienced prenatal drug exposure might have been included. Classification of some VTs as adopted-biological or adopted-adopted can also be challenging, as in the case of an adopted sibling and a co-sibling created from an unrelated embryo gestated by the rearing mother.

Research findings are most robust when convergent findings are provided by different approaches to the same class of questions. Virtual twins provide one such approach. A number of interesting issues (e.g., the effects of shared environments on age at menarche; parental favoritism toward biological vs. adopted children) would be illuminated by including VTs in the research design.

Highlights

We investigated a new twinship – virtual twins—combining it with other genetically and environmentally sensitive kinships.

Virtual twins are an exciting addition to behavioral-genetic research methods

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Table 1

Virtual Twins: Pair Types

PAIR TYPE	N	BB	GG	BG
Adop-Adop	93	23	21	49
Adop-Biol ^I	49	16	12	21
Total	142	39	33	70

^I Same-sex couple, each with a biological child.

Table 2

Descriptive Characteristics of Virtual Twins

MEASURE	MEAN	SD	RANGE
AGE DIFFERENCE IN MON [142]	3.22	2.77	0 – 9.2
AGE AT TESTING IN YEARS (275)	7.87	8.22	4.01 – 54.8
TEST INTERVAL IN DAYS [142]	4.22	24.07	0 – 255
AGE DIFFERENCE AT TESTING IN MON [142]	3.28	2.80	0 – 9.9
AGE AT ADOPTION IN DAYS (224)	56.46	91.68	0 – 373
NUMBER OF PREVIOUS LIVING SITUATIONS (221) ^I	0.67	1.02	0 – 8

(N) = individuals; [N] = pairs or families

^IData were missing for 3 individuals.

Table 3

VTs' IQ Scores and Related Data (N = 142 pairs)

Mean ¹	SD	RANGE	r _i	95% CI	DIFF ²	SD	RANGE
FULL IQ							
105.83	13.37	70–148	.28 ^{***}	(.12–.42)	12.71	9.76	0–45
VERBAL IQ							
105.25	14.03	62–150	.22 ^{**}	(.06–.37)	13.49	10.90	0–53
PERFORMANCE IQ							
105.36	13.2	70–144	.26 ^{***}	(.10–.41)	13.66	9.40	0–41

¹Individual Data (N = 275)

²Pair Data (N = 142)

* p< .05

**

p< .01

***

p< .001

Table 4

IQ Scores of Biological and Adoptive Siblings

	BIOLOGICAL n=50*		ADOPTIVE n=225		REARING STATUS
	Mean	(SD)	Mean	(SD)	r (n = 275)
1 IQ	113.04	(14.50)	104.23	(12.59)	.25**
2 VIQ	111.26	(15.82)	103.91	(13.28)	.20**
3 PIQ	111.98	(13.52)	103.89	(13.23)	.23**

1 t (273)=-4.35, p< .001

2 t (273)=-3.41, p< .01

3 t (273)=-3.89, p< .001

**
p< .01

* There are 49 biological-adopted pairs, but 50 biological children since the children of one same-sex couple are biological, but considered a biological-adopted pair.

Table 5

IQ Intraclass Correlations for Adopted-Adopted vs. Adopted-Biological VT Pairs

	Adopted-Adopted	Adopted-Biological
IQ		
Segal	.10	.47 ***
Bouchard & McGue (1981)	.34	.29
Horn et al. (1979)	.22	.26
VIQ		
Segal	.13	.33 **
Horn et al (1982)	.19	.21
PIQ		
Segal	.12	.40 **
Horn et al. (1982)	.05	.24 **

**
p< .01

***
p< .001

n (pairs): Segal: adopted-adopted (93); adopted-biological (49); Bouchard & McGue: adopted-adopted (369); adopted biological (345); Horn et al. adopted-adopted (142); adopted-biological (162)