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Childhood verbal development and drinking behaviors from adolescence to young adulthood: A discordant twin pair analysis

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Abstract

Background—Studies suggest that better cognitive and verbal abilities in childhood predict earlier experimentation with alcohol and higher levels of drinking in adolescence, whereas poorer ability is related to a higher likelihood of remaining abstinent. Whether individual differences in language development in childhood predict differences in adolescent drinking behaviors has not been studied.

Methods—To address that question, we compared co-twins from twin pairs discordant for their childhood language development and studied associations of parental reports of within-pair differences in age at speaking words, age at learning to read, and expressive language skills during school age with self-reported within-pair differences in drinking, intoxication, and alcohol-related problems across adolescence and young adulthood. Data from two longitudinal population-based samples of twin families were used, with verbal developmental differences in childhood reported by the parents when the twins were 12 and 16 years, respectively.

Results—Conditional logistic regression analyses and within-pair correlation analyses suggested positive associations between verbal development and drinking behaviors in both datasets. In analyses adjusted for birth order and birth weight, the co-twin reported to be verbally more advanced in childhood tended to report more frequent drinking and intoxication in adolescence in both samples. Better verbal development also was associated with the likelihood of having friends who drink in adolescence.

Conclusions—These findings suggest that, adjusting for familial and other factors shared by co-twins, better verbal development in childhood predicts more frequent drinking and intoxication in adolescence and young adulthood, possibly due, in part, to peer associations.

Keywords

Language development; Drinking; Intoxication; Adolescence; Discordant pairs design

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Introduction

Cognitive abilities comprise information-processing functions such as selection, storage, manipulation and organization of information (Deary et al., 2010). Individual differences in cognitive abilities contribute to differences in important outcomes including educational attainment, job performance, economic preferences, health behaviors, and mortality (Burks et al., 2009; Calvin et al., 2011; Gottfredson, 1997). Verbal ability— understanding, processing and producing meanings linguistically—is an important cognitive function which correlates strongly with general cognitive ability (Deary et al., 2010).

Because language is crucially involved in cognitive abilities, differences in language development predict later cognitive outcomes. For example, earlier speaking age predicts better cognitive ability at age 8, better school achievement in childhood and adolescence, and higher educational level and verbal ability in adulthood (Hohm et al., 2007; Murray et al., 2007; Taanila et al., 2005), and language development among preschoolers predicts reading skills in school age (Hayiou-Thomas et al., 2010).

In the quest for predictors of alcohol problems, researchers have also assessed the role of cognitive abilities. Large-scale longitudinal studies have found poorer cognitive abilities in adolescence and early adulthood to predict increased risk for alcohol-related morbidity and mortality among drinkers several years later (Gale et al., 2008; 2010, Sjölund et al., 2012). Individual differences in specific cognitive functions are also risk factors for drinking behaviors. Notably, variation in executive functions, or cognitive control, has strong associations with alcohol and drug use behaviors (Clark et al., 2008).

Other longitudinal studies have investigated whether cognitive ability predicts initiation of alcohol use and variation in drinking patterns in adolescence and adulthood. Contrary to findings on alcohol-related problems, cohort studies have found <u>better</u> cognitive test performance in childhood to predict earlier experimentation with alcohol and higher levels of drinking in adolescence and adulthood, whereas poorer ability has been linked to a higher likelihood of remaining abstinent (Batty et al,. 2008; Hatch et al., 2007; Jefferis et al., 2008; Kanazawa and Hellberg, 2010; Wilmoth, 2012). The origins of these associations are poorly understood. Specifically, while previous studies have assessed school-aged children with standard tests of cognitive ability, it is not known whether individual differences in early childhood cognitive development predict future drinking behaviors. For example, large variation in language development exists (Fenson et al., 1994). As reviewed above, there is continuity between childhood verbal development and cognitive ability up to adulthood, but associations between language development and later substance use behaviors are unknown. To better understand the role of cognitive abilities in the development of alcohol use, investigating such early developmental indicators would be important.

Cognitive and verbal development could be predictive of drinking behaviors due to several factors. Peer influences and the tendency to seek novel experiences could link better verbal development with drinking behaviors. Good language skills reduce the likelihood of peer rejection (Braza et al., 2009; Menting et al., 2011) whereas higher social activity predicts more frequent drinking in adolescence (Pitkänen et al., 2008). The personality trait novelty seeking is positively associated with alcohol use (Zuckerman and Kuhlman, 2000), and cognitive performance and reading abilities in childhood are related to higher stimulation seeking tendencies (Raine et al., 2002).

Associations between better cognitive development and experimentation with alcohol might merely reflect confounding by familial background. Higher parental education and income are positively associated with early cognitive and verbal development (Kelly et al., 2011; Schjølberg et al., 2011), and alcohol use may be more common among adolescents from higher-income households (Melotti et al., 2011). As familial factors are difficult to measure and fully control using statistical adjustments, their contribution to the relation of cognitive development and drinking behavior is uncertain.

In the present study, we hypothesize that individual differences in childhood verbal development are associated with drinking behaviors from early adolescence to young adulthood. In two longitudinal population-based samples of twin families, we use the twins' frequency of drinking and intoxicating and self-reported problems related to alcohol use as indicators of drinking behaviors. As indicators of verbal development, we use parental reports of age at speaking words and learning to read, and expressive language skills during school age. We know of no previous studies that used such early information to investigate associations between cognitive development and the development of alcohol use behaviors.

We use the discordant co-twin design. By examining drinking behaviors within like-sexed twin pairs whose members are discordant for verbal development, we aim to minimize the possible confounding effects of sex, age, and birth cohort, as well as familial confounding factors shared by the co-twins. The within-pair comparison also adjusts for all genetic influences among genetically identical monozygotic (MZ) twins and part of the genetic influences among dizygotic (DZ) twins who share, on average, 50% of their segregating genes. Thus, the aim of the present analysis was to investigate whether childhood verbal development is associated with drinking behaviors in adolescence independently of familial background.

Materials and Methods

Sample

Data came from two ongoing studies of Finnish twins, *FinnTwin12* (FT12) and *FinnTwin16* (FT16). Both FT16 and FT12 are longitudinal studies of five consecutive birth cohorts (1975–1979, and 1983–1987, respectively) of Finnish twins, identified via Finland's Population Register Centre (Kaprio et al., 2002). In both studies zygosity was determined from questionnaire items concerning the twins' similarity and confusability, completed by both co-twins and their parents at the baseline. In subsets of like-sexed twins, zygosity was confirmed with highly polymorphic genetic markers. Study protocols of FT16 and FT12 were approved by the Ethical Committee of the University of Helsinki and the IRB of Indiana University. Parents provided written informed consent for their and their children's participation.

In both studies, four waves of study have been completed. In FT16, after the baseline data collection at age 16 years (N = 2,733 families, response rate 88%), questionnaire surveys were repeated at ages 17 yrs, 18.5 yrs, and between ages 23 and 25 yrs in young adulthood. Consistently high response rates have been achieved, with participation being ~90% at each wave of data collection (Kaprio, 2006; Kaprio et al., 2002).

After baseline data collection at age 11–12 in FT12 (N = 2,724 families, response rate 87%), this sample has been followed up with questionnaire surveys at ages 14 yrs, 17.5 yrs, and as young adults between ages 20 to 24 yrs, again with low levels of non-response. Nested within the full population-representative FT12 study is a more intensive assessment of a sub-sample of 1,035 families of twins. This sample includes twins assumed to be at elevated familial risk for alcoholism based on their parents' responses on an 11-item diagnostic screen for alcohol-related problems, added to a random sub-sample drawn from the full FT12 study. The items on alcohol use at age 12, included in the present analysis, were available only from this smaller intensively studied sample of FT12 twins.

At baseline, a family questionnaire was sent to the twins' parents and usually completed by the twins' mother. Besides information about the twins' gestation and delivery, it included questions on the early development of the twins, including verbal development. Family questionnaires were available for a total of 1,706 like-sexed (839 MZ, 867 DZ) twin pairs in FT16, and for 1,654 like-sexed (832 MZ, 822 DZ) pairs in FT12. Parental reports of the twins' diagnoses (coded using ICD-9) of congenital and other long-term diseases were inspected, and twin pairs in which one or both co-twins had a diagnosis judged to potentially affect verbal development were excluded. Examples of such diagnoses include mental retardation, cerebral palsy, minimal brain dysfunction, cleft lip or palate, epilepsy, and severe hearing impairment. After these exclusions, 1,593 (794 MZ, 799 DZ) eligible like-sexed pairs in FT16 and 1,578 (804 MZ, 774 DZ) pairs in FT12 remained.

Measures

Verbal development was evaluated with three indicators: age at speaking words, age at learning to read, and expressive language skills during elementary school (specifically: age 7–12 in FT16, age 7–10 in FT12). Importantly, the items inquired of differences between co-twins, asking whether one of the twins had led the other in the development of the respective skill or outcome, for example learning to read first. Response options were: (1) The first born twin (twin A) was ahead, (2) The second born twin (twin B) was ahead, (3) There was no difference (for example, both co-twins learned to read within one month), and (4) Can't say. There were two exceptions to this general response format. First, the item on verbal expression during school age was part of a list of questions that had five response options: (1) Twin A was clearly more advanced, (2) Twin A was slightly more advanced, (3) No difference, (4) Twin B was slightly more advanced, and (5) Twin B was clearly more advanced. Second, in FT16, the age (in months) at which each co-twin learned to speak words was asked. In order to analyze all developmental indicators in a uniform manner, information from all items was re-structured into variables with three categories: (1) Twin A was ahead, (2) Twin B was ahead, and (3) There was no difference. "Can't say" responses were treated as missing data. The reported age at speaking words, available in FT16, is presented as descriptive information, but was not analyzed in detail due to the unknown reliability of an age estimate reported retrospectively some 15 years later.

Multiple variables concerning alcohol use were available. Frequency of drinking and intoxicating were repeatedly asked at each wave of data collection in both samples. The structured questions varied somewhat between samples and study waves, the most common format including nine ordered categories for frequency of alcohol use, ranging from "I do not use alcohol" to "Daily", and four ordered categories for frequency of intoxication, ranging from "Never" to "Once a week or more often". These frequency variables have been used in a number of previous studies (Dick et al., 2011b; Pagan et al., 2006; Rose et al., 1999; Viken et al., 1999). Due to small numbers in some categories in the conditional logistic regression analysis (see below), responses to these items were re-coded into variables with three or four ordered categories, based on the distribution of responses. Ever using alcohol without parents around at age 12 was asked in the intensively studied sub-sample of FT12.

Problems related to alcohol use were reported in young adulthood in both samples with the Malmö-Modified Michigan Alcoholism Screening Test (Mm-MAST) (Seppä et al., 1990). The original Mm-MAST is a 9-item self-report scale of current drinking patterns and problems, designed for use in Nordic countries. The scale used in FT16 and FT12 had 2 additional items overlapping with DSM diagnostic criteria. Each item had a "Yes" or "No" response option and the sum of "Yes" responses was calculated as the Mm-MAST score. This scale had high internal consistency in both FT12 (coefficient alpha = .80) and FT16 (coefficient alpha = .77). Both studies also included a variable, reported in young adulthood, on maximum amount of alcoholic drinks consumed within 24 hours, shown to be an effective screen for hazardous drinking (Dawson et al., 2010). In addition to these shared indicators of alcohol problems, FT16 included the Rutgers Alcohol Problem Index (RAPI) (White and Labouvie, 1989) administered at age 18.5 and in young adulthood. RAPI is a self-report measure of alcohol-related problems experienced during the previous 12 months. The original RAPI has 23 items, but in FT16 the item on whether alcohol use interfered with school work or examination preparation was omitted, creating a 22-item Finnish adaptation of RAPI with four response options. The internal consistency of RAPI was excellent at age 18.5 (coefficient alpha = .88) and in young adulthood (coefficient alpha = .90). The age 18.5 RAPI scores have been found to robustly predict alcohol DSM diagnoses in young adulthood (Dick et al., 2011a).

To validate the parental reports of verbal developmental differences between co-twins, this information was contrasted against the twins' educational attainment and verbal ability in young adulthood. Education was self-reported as the highest diploma and coded into four categories ranging from compulsory schooling only to academic tertiary education in the full FT16 and FT12 samples. Verbal ability was assessed with the WAIS-R Vocabulary subtest (Wechsler, 1981) in young adulthood in more intensively studied sub-samples of 602 twins in FT16 and 812 twins in FT12 (for description of the sub-samples, see: Kaprio et al., 2002; Latvala et al., 2011; Vuoksimaa et al., 2012).

Analyses

Because the indicators of verbal development provided information only on the order of development between co-twins within twin pairs, direct associations between absolute levels of verbal development and alcohol use behaviors could not be investigated. Instead, associations between co-twin order in verbal development and alcohol use variables were analyzed using conditional logistic regression analysis. In conditional logistic regression, matched pairs that are discordant for both the outcome and for the predictor provide information for the estimation of the model's parameters (Breslow, 1996; Hosmer and Lemeshow, 2000). In the present study, this implied that only twin pairs who were reported to differ in verbal development (i.e. either twin A or twin B was reported to have been ahead in development) and who reported different levels of alcohol use provided information for the estimation of the association between the two; pairs in which co-twins did not differ in verbal development or levels of alcohol use did not contribute to the logistic regression analysis.

Because most of the alcohol variables were not dichotomous, they could not function as outcome variables in the logistic regression models (i.e. denote case vs. control status, as used in standard epidemiological models). Instead, the order within pairs on the indicators of verbal development served as the outcome variable, where value 1 denoted the more advanced co-twin, and value 0 denoted the less advanced co-twin, for each of the three indicators. The raw alcohol variables served as predictors in the conditional logistic regression models. Even though the actual predictor variable (i.e., verbal developmental indicator) thus served as the outcome in these models, the model parameters provide evidence for the strength of the association between the two variables. Birth order and birth weight were included as covariates. Heterogeneity between MZ and DZ pairs was assessed by testing the significance of an interaction term with zygosity, and models were estimated separately for the two zygosities.

In addition to assessing each verbal developmental indicator separately in the conditional logistic regression analysis, a summary variable for within-pair verbal developmental differences was constructed. This variable was created by summing over the three developmental indicators (speaking words, reading, expressive language) such that for each indicator, value 1 was assigned if twin A was the more advanced co-twin, and value −1 was assigned if twin B was the more advanced co-twin. If no difference was reported for the given indicator, value 0 was assigned. Summing over the three indicators, this variable thus had a maximum value of 3 and a minimum value of −3 (i.e. in pairs where twin A and twin B was reported to be ahead in each of the three indicators, respectively). This sum of within-pair developmental differences was correlated with within-pair differences in alcohol variables, created for each variable by subtracting twin B's value from twin A's value, using polychoric and polyserial correlations. This within-pair correlation analyses thus utilized information from the entire sample, including pairs where no differences in verbal development or drinking variables were reported.

Results

Descriptives

Numbers and proportions of MZ and like-sexed DZ twin pairs who were discordant and concordant for each of the verbal developmental indicators are given in Table 1. As expected, many more developmental differences were reported for DZ than for MZ co-twins. The rates of discordance were also different for the three developmental indicators, with highest levels of discordance reported for expressive language in elementary school (43.4% in FT12, 34.4% in FT16) and lowest levels for age at speaking words (26.0% in FT12, 17.0% in FT16). Overall, somewhat higher levels of discordance were reported in FT12 than in FT16.

The reported order of verbal development within twin pairs was generally not statistically significantly related to birth order, an exception being age of speaking words in FT16. Here, twin A was more likely to be the earlier speaking twin ($p= 0.0097$, Table 1). However, verbal development was related to birth weight. Within discordant pairs, the earlier speaking co-twin was born on average 51 g heavier than his/her later speaking co-twin in FT12 ($p=0.023$), and 66 g heavier in FT16 ($p=0.029$). In addition, the earlier reading co-twin in FT16 was born on average 68 g heavier than the later reading co-twin ($p=0.0030$).

The reported mean age at speaking words in FT16 (N=2,358 individuals) was 14.6 months (95% CI: 14.4–14.8). There was a highly significant sex difference, with girls reported to having spoken words at an average age of 13.9 months and boys at 15.4 months ($p<0.001$). The reported age of speaking words was not related to zygosity.

The distributions of drinking behaviors in these data have been extensively reported earlier (Dick et al., 2009; 2011a; Latvala et al., 2011; Pagan et al., 2006; Rose et al., 1999; 2001; Viken et al., 1999; 2007), and are not presented here in detail. In both samples, the prevalence of drinking and intoxicating increased with age, and by age 17, a majority of twins reported engaging in these behaviors. The proportion of twin pairs discordant for frequency of drinking or intoxication varied between 26.6% and 49.8% across age in FT16, and between 17.3% and 41.4% in FT12. A clear exception was the low prevalent age 12 FT12 variable of having drunk with friends, for which only 6.7% of the pairs with this information were discordant. Rates of discordance for alcohol variables were higher among twin pairs discordant for verbal development, ranging from 30.7% to 54.9% in FT16, and from 20.0% to 47.6% in FT12 (7.8% for drinking with friends at age 12).

The number of doubly discordant pairs varied for each pair of developmental and alcohol variables. On average, 151 pairs were available for analyses in FT12 (median=138, range: 9–428 pairs), and 192 pairs in FT16 (median=164, range: 61–448 pairs). A statistically significant association within such pairs can be demonstrated with only six pairs provided the 'exposure' is consistently associated with the 'outcome'.

Associations between verbal development and drinking behaviors

Odds ratios from the conditional logistic regression models for alcohol use variables and verbal developmental indicators, adjusting for birth order, birth weight and zygosity, are given in Tables 2 and 3. These models indicated that being the verbally more developed co-twin in childhood tended to be related to an increased likelihood of drinking more frequently (or, a decreased likelihood of drinking less frequently) at age 14 in FT12, and at each of the four time points in FT16. An exception to this pattern of results was the seen in FT16 for learning to read and drinking at age 18.

Verbal development was also associated with the frequency of intoxication. In FT12, the earlier reading co-twin was more likely than the later reading co-twin to report intoxication at least once a month in young adulthood, as compared to less than once a month (Table 2: OR=2.65, p=0.044; OR=5.47, p=0.033). In FT16, expressive language skills in elementary school were associated with intoxication at ages 17 and 18, and in young adulthood (Table 3). Finally, these verbal developmental indicators, with the exception of reading, were also weakly positively associated with max drinks in both samples (FT12: p=0.032, FT16: p=0.042), and with Mm-MAST in FT16 (p=0.028). The associations between verbal development and drinking variables were not systematically different in brother-brother and sister-sister twin pairs (results not shown).

In the correlation analysis of within-pair differences in the full samples, small but statistically significant positive correlations were found for being more advanced in verbal development and drinking outcomes. In FT12, the within-pair verbal developmental summary score correlated positively with within-pair differences in the frequency of drinking at age 14 (polychoric rho=0.08, p=0.011), and frequency of intoxication in young adulthood (polychoric rho=0.09, p=0.023). Similarly, within-pair differences in verbal development in FT16 correlated positively with within-pair differences in the frequency of drinking at 16 (polychoric rho=0.08, p=0.025) and at 17 (polychoric rho=0.07, p=0.043), as well as frequency of intoxication at 16 (polychoric rho=0.09, p=0.013) and at 18 (polychoric rho=0.11, p=0.0027).

Heterogeneity between MZ and DZ pairs

In all the conditional logistic regression analyses reported above, interactions with zygosity were non-significant, indicating that the associations between verbal development and drinking behaviors could not be shown to differ between MZ and DZ twin pairs. In some cases, this was due to limited statistical power, because small numbers of MZ pairs were discordant both for verbal development and drinking outcomes (often less than 30 pairs). In separate conditional logistic models for each zygosity, associations between verbal development and drinking behaviors were often observed in DZ but not in MZ pairs (see Supplementary tables). Similarly, of the significant within-pair differences correlations, many were entirely driven by the DZ correlation. Finding an association within DZ but not MZ pairs would suggest that the association is confounded by genetic influences. However, in some cases the estimated associations were similar within MZ and not DZ pairs (see Supplementary tables).

Associations of childhood verbal development with verbal ability and educational level in young adulthood

In both samples, there was a positive correlation between co-twin differences in childhood verbal development and co-twin differences in Vocabulary scores in young adulthood within DZ but not MZ pairs. A polyserial correlation of 0.34 ($p<0.001$) was observed in the 115 like-sexed DZ twin pairs with Vocabulary data in FT12, and a similar coefficient of 0.31 ($p<0.01$) was present among the 73 like-sexed DZ twin pairs in FT16. Similarly, positive correlations were observed between verbal developmental differences and differences in educational attainment within DZ but not MZ pairs in both samples. A polychoric correlation of 0.27 ($p<0.001$) was observed in like-sexed DZ twin pairs in FT12, and a coefficient of 0.22 ($p<0.001$) was found in FT16.

Complementary analyses

Two additional, exploratory within-pair correlation analyses were conducted. Because adolescent drinking is usually social behavior, differences in interpersonal skills and behaviors could contribute to the positive association between cognitive abilities and drinking behaviors in adolescence (Windle and Blane, 1989). We had information on friends' drinking available from both samples, and we found small but statistically significant positive correlations between the summary score of within-pair differences in verbal development and within-pair differences in the number of friends who drink at age 17 in both FT12 (polychoric rho=0.10, p=0.008) and in FT16 (polychoric rho=0.09, p=0.033). Another additional analysis tested whether tendencies to seek novel experiences, demonstrably related to drinking behaviors, might be associated with verbal development; 24 items of the Sensation Seeking Scale (Zuckerman, 1979) were administered in FT16 at ages 17 and 18. The summary score of within-pair differences in childhood verbal development were found to be positively, albeit weakly, correlated with within-pair differences in the Experience Seeking subscale at both ages (age 17: polychoric rho=0.08, p=0.034; age18: polychoric rho=0.07, p=0.043).

Discussion

In two independent, population-based samples of twins, associations between co-twin order in verbal development in childhood and differences in alcohol use behaviors across adolescence and young adulthood were studied. Jointly, the findings are suggestive of a within-pair relationship between better verbal development and engaging in drinking behaviors, although that association was not found for all verbal developmental and drinking variables. In both samples, the earlier speaking co-twin tended to report more frequent drinking than the later speaking co-twin at some point in adolescence. In addition, the twin who learned to read before his/her co-twin did, was more likely to report more frequent drinking or intoxication in young adulthood in both samples. Finally, the co-twin whom the parents considered to be more advanced in expressive language skills during elementary school was less likely to be an abstainer at age 16, and was more likely to report frequent drinking in young adulthood, as well as intoxication across adolescence and in young adulthood. Within twin pairs, verbal development was also positively related to having consumed a larger amount of alcohol within 24 hours in both samples, and to reporting more alcohol-related problems in one of the samples, although these associations were rather weak.

To our knowledge, no previous study has assessed the association between verbal development in early childhood and later development of alcohol use behaviors. Our findings thus extend evidence from earlier studies suggesting that better cognitive abilities in school-aged children and adolescents may relate to a higher likelihood of reporting drinking and some alcohol-related problems (Batty et al., 2008; Hatch et al., 2007; Jefferis et al., 2008; Kanazawa and Hellberg, 2010; Wilmoth, 2012; Windle and Blane, 1989).

The present analysis extends earlier research in another important way. The associations between verbal development and drinking behaviors were observed within twin pairs, indicating that these associations were not confounded by familial influences shared by co-twins, such as factors related to parents or the rearing environment. Nor were the associations influenced by gender differences in verbal development and drinking behaviors, as only like-sexed twin pairs were studied. However, the findings were not unequivocal regarding the role of genetic influences, because the relatively small samples informative for conditional logistic regression analyses did not permit robust testing within MZ and DZ pairs.

Complementary analyses revealed that having been verbally more advanced in childhood was also related to an increased likelihood in adolescence to have friends who drink and to report higher levels of experience seeking than the verbally less advanced co-twin. Seeking novel experiences and having drinking peers are associated with higher levels of alcohol use, and these factors might link verbal development with drinking behaviors. But most adolescents report having drinking friends, so these results indicate that youth with better verbal development were more likely to belong to this majority.

For interpretation of the results, it should be recalled that in most twin pairs the co-twins did not differ in verbal development, and of the pairs that did differ, in less than half the co-twins were discordant for alcohol use. Second, none of the associations were strictly replicated in both studied samples. We can only speculate the reasons behind this inconsistency. Data collection for FT16 took place a decade earlier than that for FT12, and important differences between these periods in Finland do exist. FT16 twins were adolescents in the middle of a serious economic depression, whereas FT12 twins grew up during an economic boom. Such macro-environmental contextual factors may have influenced the results in a complex manner (Rose et al., 1999).

Further, the current findings could potentially be due to some unknown, pre-existing differences between co-twins, present prior to verbal development. Finally, cooperative sibling interaction effects on substance use could have been affected the results (Penninkilampi-Kerola et al., 2005; Rhee et al., 2003; Rose et al., 1999). Such effects may have reduced differences in drinking between co-twins and thus weakened the association between verbal development and alcohol use.

This study has some important limitations. First, only retrospective parental reports of verbal development were available. Such reports may be biased by several factors, most notably by parental perceptions of the child’s later development and behavior. Second, with one exception, information was available only on the within-pair order of verbal development in co-twins, which limited the present analyses. Parents are likely to note and recall clear differences between co-twins in the timing of reaching important developmental milestones, such as speaking words, but without information on the magnitude of co-twin differences, the meaningfulness of these data can be questioned. We were able to investigate this issue with the item on expressive language skills during elementary school. This item originally had the response options “Slightly more advanced” and “Clearly more advanced”, which were collapsed for the analyses (see Methods). Using only pairs with a “clear difference” in expressive language skills produced fairly similar results as the whole sample. Some evidence for a stronger association in more discordant pairs was also found (results available from the corresponding author).

Validity of the parental reports of developmental differences was supported by the observation, in both samples, that better verbal development as reported by parents predicted better verbal ability, assessed with a standard neuropsychological test, and higher educational level, reported by the twins, in DZ but not in MZ twin pairs, compatible with genetic influences on the continuity of verbal and cognitive abilities (Deary et al., 2000; Hayiou-Thomas et al., 2012). However, we cannot fully exclude the possible effect of rater bias in parental reports (Bartels et al., 2007) of verbal developmental differences.

A third potential limitation is that data on complex verbal developmental phenomena were collected with single items, ambiguous for their exact meaning. For example, "speaking words" could denote several different stages of early expressive language development (Fenson et al., 1994).

Strengths of the present study include the use of two large and independent population-based samples with extensive information on the development of alcohol use spanning from early adolescence to emerging adulthood. The within-pair design had the notable strength of controlling for all potential confounding factors shared by co-twins.

In conclusion, the present study found that within like-sexed twin pairs, the co-twin that parents reported as more advanced in language development in childhood was more likely to report more frequent drinking and intoxication in adolescence and young adulthood. Results mostly related verbal development to engaging in normative drinking behaviors. Longitudinal studies with representative samples and informative study designs are required to chart the development of the complex connections between cognitive factors and drinking behaviors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Distributions of the indicators of verbal developmental differences within monozygotic (MZ) and like-sexed dizygotic (DZ) twin pairs in the FT12 and FT16 samples.

	FT12						FT16					
	Total		MZ		DZ		Total		MZ		DZ	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Speaking words												
Twin A ahead	214	(14.15)	81	(10.41)	133	(18.12)	115	(10.08)*	30	(5.11)	85	(15.34)
Twin B ahead	179	(11.84)	52	(6.68)	127	(17.30)	79	(6.92)*	20	(3.41)	59	(10.65)
No difference	1119	(74.01)	645	(82.90)	474	(46.58)	947	(83.00)	537	(91.48)	410	(74.01)
Reading												
Twin A ahead	244	(15.78)	73	(9.32)	171	(22.41)	179	(11.60)	35	(4.57)	144	(18.53)
Twin B ahead	236	(15.27)	53	(6.77)	183	(23.98)	179	(11.60)	43	(5.61)	136	(17.50)
No difference	1066	(68.95)	657	(83.91)	409	(53.60)	1185	(76.80)	688	(89.82)	497	(63.96)
Expressive language												
Twin A ahead	350	(22.34)	118	(14.77)	232	(30.21)	268	(17.11)	74	(9.43)	194	(24.84)
Twin B ahead	329	(21.00)	126	(15.77)	203	(26.43)	270	(17.24)	74	(9.43)	196	(25.10)
No difference	888	(56.67)	555	(69.46)	333	(46.36)	1028	(65.64)	637	(81.15)	391	(50.06)

* Difference by birth order: proportions of pairs with twin A ahead vs. twin B ahead differ significantly (p=0.0097)

Twin A = the first born twin; Twin B = the second born twin.

Table 2

Associations (Odds ratios) between verbal development and drinking behaviors in monozygotic and like-sexed dizygotic twin pairs in the FT12 sample.

	Speaking words		Reading		Expressive language	
	OR	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Drinking at 12: Never	1.00	(referent)	1.00	(referent)	1.00	(referent)
Have drunk with friends	0.34	(0.03–4.15)	1.15	(0.07–19.4)	1.34	(0.35–5.08)
Drinking at 14: Never	1.00	(referent)	1.00	(referent)	1.00	(referent)
Less than once per month	1.08	(0.41–2.85)	1.75	(0.55–5.57)	0.93	(0.47–1.82)
More often	**5.50***	(1.08–27.9)	4.00	(0.74–21.6)	0.72	(0.27–1.94)
Drinking at 17: Never	0.69	(0.17–2.90)	0.65	(0.12–3.55)	0.68	(0.24–1.95)
Less than once per month	1.47	(0.45–4.83)	0.82	(0.27–2.43)	0.94	(0.48–1.85)
Once or twice per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
More often	0.66	(0.26–1.65)	0.94	(0.39–2.27)	1.42	(0.73–2.76)
Drinking at 22: Less than once per month[1]	0.43	(0.12–1.56)	0.39	(0.10–1.55)	0.80	(0.33–1.96)
Once or twice per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
Once a week	0.44	(0.18–1.10)	1.97	(0.70–5.57)	1.25	(0.62–2.53)
More often	0.56	(0.18–1.74)	0.77	(0.21–2.78)	1.44	(0.59–3.53)
Drunk at 14: Never	1.00	(referent)	1.00	(referent)	1.00	(referent)
Less than once per month	1.15	(0.38–3.53)	1.44	(0.39–5.32)	0.55	(0.25–1.21)
More often	0.55	(0.07–4.21)	1.33	(0.24–7.33)	0.85	(0.24–3.06)
Drunk at 17: Never	0.60	(0.15–2.46)	0.72	(0.23–2.29)	1.05	(0.47–2.34)
Less than once per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
Once or twice per month	1.78	(0.76–4.17)	0.94	(0.44–1.99)	1.20	(0.68–2.14)
More often	1.36	(0.34–5.35)	2.51	(0.60–10.6)	0.90	(0.35–2.36)
Drunk at 22: Never	2.52	(0.22–29.31)	0.93	(0.15–5.83)	0.40	(0.07–2.19)
Less than once per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
Once or twice per month	1.28	(0.53–3.11)	**2.65***	(1.03–6.84)	0.87	(0.43–1.76)
More often	2.03	(0.46–8.95)	**5.47***	(1.15–26.0)	1.03	(0.35–3.00)
Mm-MAST at 22	1.13	(0.93–1.37)	1.17	(0.92–1.49)	1.21	(0.99–1.48)
Max drinks at 22	**1.08***	(1.01–1.16)	1.05	(0.99–1.11)	1.04	(1.00–1.09)

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[*] $p<0.05$

[1] This category includes non-drinkers

OR = odds ratio; CI = confidence interval; Mm-MAST = Malmö-Modified Michigan Alcoholism Screening Test.

Odds ratios are from conditional logistic regression models adjusting for birth order, birth weight, and interaction with zygosity, and denote the odds ratio of each drinking variable as a predictor of each verbal developmental indicator (1=verbally more advanced co-twin, 0=verbally less advanced co-twin).

Table 3

Associations (Odds ratios) between verbal development and drinking behaviors in monozygotic and like-sexed dizygotic twin pairs in the FT16 sample.

	Speaking words		Reading		Expressive language	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Drinking at 16: Does not drink	0.56	(0.23–1.39)	0.64	(0.31–1.29)	**0.55***	(0.31–0.96)
Less than once per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
Once or twice per month	1.18	(0.62–2.26)	1.06	(0.63–1.79)	1.09	(0.71–1.69)
More often	1.03	(0.31–3.51)	1.37	(0.62–3.04)	1.42	(0.77–2.67)
Drinking at 17: Does not drink	**0.31***	(0.10–0.96)	0.52	(0.23–1.18)	0.54	(0.28–1.03)
Less than once per month	**0.47***	(0.24–0.94)	0.99	(0.61–1.59)	0.91	(0.61–1.37)
Once or twice per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
More often	0.47	(0.19–1.13)	1.15	(0.63–2.11)	1.35	(0.81–2.26)
Drinking at 18: Does not drink	0.48	(0.13–1.75)	0.66	(0.21–2.03)	0.44	(0.17–1.13)
Less than once per month	1.06	(0.51–2.21)	**1.77***	(1.02–3.05)	0.82	(0.50–1.32)
Once or twice per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
More often	1.15	(0.60–2.17)	1.43	(0.90–2.27)	1.24	(0.85–1.81)
Drinking at 25: Less than once per month[1]	0.46	(0.19–1.13)	1.06	(0.58–1.93)	0.65	(0.38–1.10)
Once or twice per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
Once a week	0.63	(0.29–1.37)	1.37	(0.80–2.35)	1.02	(0.66–1.57)
More often	0.75	(0.33–1.73)	**1.88***	(1.03–3.44)	**1.96****	(1.19–3.22)
Drunk at 16: Never	1.00	(referent)	1.00	(referent)	1.00	(referent)
Less than once per month	**2.59***	(1.18–5.67)	0.91	(0.54–1.54)	1.35	(0.85–2.14)
More often	**4.41***	(1.31–14.9)	2.11	(0.96–4.62)	1.41	(0.78–2.54)
Drunk at 17: Never	0.52	(0.26–1.05)	0.97	(0.58–1.64)	**0.50****	(0.31–0.80)
Less than once per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
Once or twice per month	1.24	(0.48–3.23)	0.94	(0.51–1.73)	1.00	(0.63–1.59)
More often	0.58	(0.10–3.34)	0.95	(0.31–2.97)	1.12	(0.45–2.80)
Drunk at 18: Never	0.68	(0.34–1.36)	0.92	(0.53–1.59)	0.67	(0.41–1.10)
Less than once per month	1.00	(referent)	1.00	(referent)	1.00	(referent)

	Speaking words		Reading		Expressive language	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Once or twice per month	1.50	(0.73–3.11)	1.15	(0.68–1.93)	**1.85****	(1.21–2.83)
More often	1.69	(0.44–6.51)	1.37	(0.51–3.63)	0.97	(0.45–2.09)
Drunk at 25: Never	0.57	(0.18–1.81)	0.59	(0.25–1.44)	**0.38***	(0.18–0.81)
Less than once per month	1.02	(0.52–1.97)	0.65	(0.39–1.08)	0.70	(0.46–1.04)
Once or twice per month	1.00	(referent)	1.00	(referent)	1.00	(referent)
More often	0.60	(0.22–1.65)	0.99	(0.53–1.85)	1.39	(0.81–2.37)
RAPI at 18	1.05	(1.00–1.10)	1.02	(0.99–1.05)	1.00	(0.97–1.02)
RAPI at 25	0.98	(0.93–1.02)	0.99	(0.97–1.02)	1.01	(0.98–1.04)
Mm-MAST at 25	1.01	(0.88–1.16)	1.05	(0.97–1.15)	**1.08***	(1.01–1.16)
Max drinks at 25	1.01	(0.98–1.05)	1.00	(0.98–1.03)	**1.02***	(1.00–1.05)

*p<0.05,

**p<0.01

[1]This category includes non-drinkers

OR = odds ratio; CI = confidence interval; RAPI = Rutgers Alcohol Problem Index; Mm-MAST = Malmö-Modified Michigan Alcoholism Screening Test.

Odds ratios are from conditional logistic regression models adjusting for birth order, birth weight, and interaction with zygosity, and denote the odds ratio of each drinking variable as a predictor of each verbal developmental indicator (1=verbally more advanced co-twin, 0=verbally less advanced co-twin).

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