

VARPU PENNINKILAMPI-KEROLA

**IMPLICATIONS OF CO-TWIN DEPENDENCE FOR TWINS'
SOCIAL INTERACTIONS, MENTAL HEALTH AND ALCOHOL
USE**

A follow-up study of Finnish twins from adolescence to early
adulthood

ACADEMIC DISSERTATION

To be presented, with the permission of the Faculty of Medicine of the
University of Helsinki, for public examination in the Auditorium 12 of
Department of Paediatrics, University of Oulu on August 25th, 2006, at 12
noon.

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ISSN 0355-7979

ISBN 952-10-1372-9 (paper back)

ISBN 952-10-3194-8 (PDF, <http://etheisis.helsinki.fi>)

Painting: Tiina Timlin

Abstract

Background and objective: Relatively few studies have concentrated on the qualities or implications of the relationships between twins and their co-twins. The aim of the present study was to examine co-twin dependence and its impact on twins' social contacts, leisure-time activities and psycho-emotional well-being. The role of co-twin dependence was also examined as a moderator of genetic and environmental influences on alcohol use in adolescence and in early adulthood.

Methods: The present report is based on the Finnish Twin Cohort Study (FinnTwin16), which is a population-based study of five consecutive birth cohorts of Finnish twins born in the years 1975-1979. Baseline assessments were collected through mailed questionnaires during the years 1991-1995, within two months of the twins' sixteenth birthday. The five-year cohort yielded replies from 5563 twin individuals. All respondent twins were sent follow-up questionnaires at ages of 17, 18½, and in early adulthood, when twins were 22-27 years old.

Measures: The questionnaires included a survey of health habits and attitudes, a symptom checklist and questions about twins' relationships with parents, peers and co-twin. Measures used were twins' self-reports of their own dependence and their co-twin's dependence at age 16, reports of twins' leisure-time activities and social contacts, alcohol use, psychological distress and somatic symptoms both in adolescence and in early adulthood.

Results: Co-twin dependence is relatively common feature among twins. In the present study 25.6% of twins reported dependence on their co-twin. There were gender and zygosity differences in dependence, females and MZ twins were more likely to report dependence than males and DZ twins. The results also suggested that co-twin dependence can be viewed on one hand as an individual characteristic, but on the other hand as a pattern of dyadic interaction that is mutually regulated and reciprocal. Most of the twins (80.7%) were either concordantly co-twin dependent or concordantly co-twin independent. The associations of co-twin dependence with twins' social interactions and psycho-emotional characteristics were relatively consistent both in adolescence and in early adulthood. Dependence was related to higher contact frequency and a higher proportion of shared leisure-time activities between twin siblings at the baseline and the follow-up. Additionally co-twin dependence was associated with elevated levels of

psycho-emotional distress and somatic complaints, especially in adolescence. In the framework of gene-environment interaction, these results suggest that the genetic contribution to individual differences in drinking patterns is dependent on the nature of the pair-wise relationship of twin siblings.

Conclusions: The results of this study indicate that co-twin dependence is a genuine feature of the co-twin relationship. This study clearly shows the importance of studying the impact of various features of co-twin relationships on individual twins' social and psycho-emotional life and well-being. Present study also offers evidence that differences in inter-personal relationships contribute to the effects of genetic propensities. Therefore, it is increasingly important not only to study the relative proportions of genetic versus environmental influences, but also to address how these influences are mediated in different sub-populations and psycho-social contexts.

Keywords: co-twin dependence, co-twin relationship, twins, social interaction, mental health, psychological distress, alcohol use, population-based

Acknowledgements

This research was carried out in Twin Research Unit of the Department of Public Health, at the University of Helsinki, in collaboration with the Clinic of Child Psychiatry of the Department of Pediatrics at the University of Oulu. I wish to express my sincere gratitude to the following co-workers, without whom this study would not have been completed.

I am most grateful to my supervisors Professor Jaakko Kaprio, M.D., Ph.D., Department of Public Health, University of Helsinki and Professor Irma Moilanen, M.D., Ph.D., Clinic of Child Psychiatry, University of Oulu. I have been privileged to have Professor Jaakko Kaprio as one of my thesis supervisors. His guidance, valuable comments and outstanding knowledge of scientific methods of twin studies and epidemiological research have been most important for my work. I am grateful to Jaakko for his kind willingness to help with all issues, no matter how minor. I wish to express my deepest gratitude to Professor Irma Moilanen for introducing me to the fascinating world of research and giving me my first opportunity to do my own research. Her dedication to this present study and her unfailing support, encouragement and optimism throughout these years have been indispensable for me. I also wish to express my gratitude to Irma for providing the facilities and inspiring working environment at the Clinic of Child Psychiatry.

I wish warmly to express my gratitude to Professor Richard J. Rose Ph.D., Department of Psychology, University of Indiana, for making it possible to use the valuable data of the FinnTwin16 project. Special thanks go to Torsten Winter Ph.D. and Kauko Mäkinen Licenciate of Philosophy for their help with data administration in different phases of the study. I owe my warmest thanks also to other co-authors of the original publications: Jouko Miettunen Ph.D. and to Docent Hanna Ebeling M.D., Ph.D. for participating in this research.

I also wish to thank Professor Britta Alin Åkerman Ph.D. of the Institute of Education in Stockholm and Professor Mauri Marttunen M.D., Ph.D. of the Department of Psychiatry at the University and University Hospital of Kuopio for their valuable advice and constructive criticism as well as Henry Fullenwider Ph.D. for editing the English language in different phases of my work. Financial support for my work provided by the

Doctoral Programs in Public Health and the Finnish Konkordia Foundation is gratefully acknowledged.

Without the tremendous assistance and support of a great many other people, this research could not have been done. I offer sincere thanks to them all - colleagues and personnel at the Twin Research Unit at the University of Helsinki and the Clinic of Child Psychiatry at the University of Oulu. In particular I thank my friends and colleagues in the FinnTwin12 project. I have shared my thoughts and concerns with many of you, and you have eased my journey in so many ways. Beside science, we have shared many joyful moments. It has been a pleasure to work with you all!

I am grateful to my friends, to my family and my two sons, who have balanced my life, kept my feet on the ground and relieved my stress just by being there. My heartfelt gratitude goes to my husband, Asla, for his love and support during all these years together - through thick and thin!

Finally, my deepest thanks go to twins and their families, who have participated our FinnTwin16 and FinnTwin12 –studies, without them this thesis wouldn't exist.

Oulu, May 2006

Abbreviations

A	Additive genetic effects
ACE model	Structural equation model with additive genetic effects and shared and unique environmental effects
ADE	Structural equation model with additive and dominant genetic effects and unique environmental effects
AIC	Akaike's Information Criterion
C	Common environmental effects
CI	Confidence interval
χ^2	Chi-squared
DZ	Dizygotic twins
E	Unique environmental effects
GHQ	General Health Questionnaire
MZ	Monozygotic twins
MMPI	Minnesota Multiphasic Personality Inventory
OR	Odds Ratio
OSDZ	Opposite-sex dizygotic twins
p, p-value	Significance Probability
SES	Socio-economic status
SSDZ	Same-sex dizygotic twins

List of original publications

This thesis is based on the following original publications, which are referred to in the text by the Roman numerals I-IV.

- I Penninkilampi-Kerola V, Moilanen I, Kaprio J. (2005) Co-twin dependence social interactions and academic achievement – A population-based study of adolescent twins and their parents. *Journal of Social and Personal Relationships*, 22, 519-541.
- II Penninkilampi-Kerola V, Kaprio J, Moilanen I, Ebeling H, Rose RJ. Co-twin dependence, personality and mental health – A population-based study of Finnish twins. *Twin Research and Human Genetics*, submitted.
- III Penninkilampi-Kerola V, Kaprio J, Moilanen I, Rose RJ. (2005) Co-twin dependence modifies heritability of abstinence and alcohol use: A population-based study of Finnish twins. *Twin Research and Human Genetics*, 8, 232-244.
- IV Penninkilampi-Kerola V, Miettunen J, Ebeling H. A comparative assessment of the factor structures and psychometric properties the GHQ-12 and the GHQ-20 based on data from a Finnish population-based sample. *Scandinavian Journal of Psychology*, in press.

In addition, some unpublished data have been included in this thesis.

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1 Introduction

The relationship between twins is often characterized as being closer than any other human relationship (Burlingham 1952). Although the twin relationship and the various ways in which twins influence and react to one another have been of great interest to their parents and teachers and have fascinated the public in general, the co-twin relationship - twinship - has received less research attention, especially in population-based samples. It is well acknowledged that growing up as a twin is biologically and psychologically different from growing up as a singleton. Compared to social world of singletons, that of twin children is usually characterized by a life-long and constant relationship with a same aged sibling.

Case and clinical studies have frequently conceptualized the close and intimate co-twin relationship as inherently problematic, with little or no allowance for beneficial outcomes. Empirical evidence for this psychopathological hypothesis is, however, indecisive as the study populations have usually been relatively small and highly selective. To date, twin research has been unable to determine whether the co-twin relationship has real developmental and behavioral consequences or whether it is associated with psychopathology when twin populations are studied in an epidemiological perspective. Understanding the significance and implications of the co-twin relationship can be considered important as such. For most twins the co-twin relationship is the longest-lasting relationship in their lives and often relatively consistent in its manifestations (Neyer 2002a).

For decades twin studies have contributed greatly to our understanding of the genetic factors of human development, and they have given insights into the relative contributions of genetic and environmental factors to different traits. The need to study the impact of co-twin relationships has emerged from the growing body of genetic epidemiological studies, as it has been suggested that sibling similarity is too great to be wholly attributed to siblings' shared genes and shared family influences. Such correlates as contact frequency between co-twins have been examined in relation to twins' similarity in different behavioral traits, but the results have been inconclusive (Kaprio *et al.* 1990, Lykken *et al.* 1990, Reiss *et al.* 2001a). It has been suggested that more attention should be paid to measurement issues and to the model effects of family environment and the importance of such attributes as inter- or extra-familial interpersonal

relationships (Horwitz *et al.* 2003, Reiss *et al.* 2001b). The need to describe and understand such attributes as social structural variables, e.g. community or neighborhood (Dick *et al.* 2001, Rose *et al.* 1999) and reciprocal interpersonal relationships, including the co-twin relationship is beginning to be established in recent behavioral genetic studies.

In the present study, a strong emphasis has been placed on the quality of the co-twin relationship, namely on co-twin dependence and its associations, and on the continuities and discontinuities of these associations. Co-twin dependence is studied here in relation to the dynamics of twins' social interactions, psycho-emotional characteristics and health-related behavior in a population-based sample. The co-twin relationship provides a unique developmental experience and environment that is not as well understood as it could be. This study aims to elucidate the associations of co-twin dependence both on the individual and the dyadic level, but it also provides insights into the implications of the co-twin relationship in the framework of twin designs and behavioral genetic studies.

2 Review of the literature

2.1 Growing up as a twin

Twins have always received special attention and captured the public curiosity. Research on twins has emerged in two separate traditions. Twin studies are seen as providing a natural mean of disentangling the contributions of genes and the environment and their interaction in human complex traits. The other approach has emphasized the special developmental environment of twins, i.e. how twins provide an opportunity to study an altered developmental context. Growing up as a twin has been suggested to be different from growing up as a singleton (Rutter & Redshaw 1991). One relatively common assumption has been that twins are under a handicap in terms of physical, psychological and social development.

Biological differences between twins and non-twins are usually thought to be the result of the special risks that are involved in a twin pregnancy and delivery. Twins are at greater risk of being born prematurely (Luke & Keith 1992, Keith *et al.* 1995) and of having postnatal complications compared to single-born children (Allen 1995, Alin Åkerman & Fischbein 1991, Moilanen & Rantakallio 1989). Additionally, the overall perinatal mortality rate for twins is 3-7 times higher than that for singletons (Sherer 2001). Twins are usually born smaller than singletons in terms of birth weight, length and head circumference (Buckler & Green 2004, Leroy *et al.* 1982). This is partly due to premature birth, but also to progressively slower growth in the later weeks of pregnancy. Small gestational size and low birth weight have often been suggested to place twins at increased risk of such complications as breathing problems, gastrointestinal problems or infections, and long-term complications and disabilities, such as intellectual or neurological problems (Allen 1995). After birth, twins usually catch up relatively rapidly with singletons in growth. By the age of 8-10 most twins have overcome the initial handicaps related to preterm birth and lower birth weight so that differences between them and single-born children are nearly nonexistent (Ljung *et al.* 1977, Watts & Lytton 1981, Wilson 1979). However, some studies have found height and weight differences in twins and singletons to persist into adolescence (Pietiläinen *et al.* 1999).

Several studies have reported that twins are more likely to have more often neurological and cognitive problems compared to singletons (Allen 1995, Bryan 1992, MacGillivray *et al.* 1988), indicating a higher risk of long-term disability, learning difficulties and language delay in particular. Longitudinal studies of childhood development have indicated that twins score lower on intelligence tests (Brandes *et al.* 1992, Deary *et al.* 2005; Record *et al.* 1970, Ronalds *et al.* 2005, Silva & Crosado 1985) and have inferior language development than singletons (Alin Åkerman & Fischbein 1991, Alin Åkerman & Thomassen 1991, Conway *et al.* 1980, Dale *et al.* 2000, Koch 1966, Hay *et al.* 1987, McMahon & Dodd 1997, Mittler 1970, Watts & Lytton 1981). Some studies have attributed the slightly lower performance of twins in a variety of cognitive ability and verbal tests to higher complication rate such as prematurity, retarded intra-uterine growth or problems in delivery (Alin Åkerman 2003, Alin Åkerman & Thomassen 1991, Moilanen & Rantakallio 1989, Stauffer *et al.* 1988), whereas other studies attribute these differences to environmental factors following birth, such as reduced maternal speech to twins and reduced opportunities for verbal communication with parents (Conway *et al.* 1980, Mittler 1970, Record *et al.* 1970, Watts & Lytton 1981, Wilson 1979) or to the co-twin relationship (Zazzo 1960). On the other hand, twins' language impairments are greater than their cognitive impairments, suggesting that twins' developmental problems are somewhat specific to language. However, most of the differences seem to be transitional and show only modest associations with twins' later cognitive and mental development (Moilanen & Rantakallio 1989, Posthuma *et al.* 2000). Some authors have suggested that by age of 9, twins' overall cognitive or academic abilities are not different from those of singletons (Silva & Crosado 1985), while other studies claim that the "cognitive cost" of being a twin persists at least until adolescence (Deary *et al.* 2005).

Studies of social-emotional and behavioral problems in childhood and adolescence have generally indicated that the overall risk of such problems in twins is not much different from that found in singletons (Gjone & Novik 1995, Moilanen *et al.* 1999, Moilanen & Rantakallio 1989, van den Oord *et al.* 1995, Pulkkinen *et al.* 2003), with some exceptions. Twins are found to show slightly but consistently higher levels of externalizing behaviours and higher total score on the Child Behaviour Checklist (CBCL) than singletons (Gau *et al.* 1992). Another study of Hay and O'Brien (1987) found that twins are more prone to the over-reaction in the Bristol Social Adjustment Scale compared to singletons. Some studies have also reported a higher incidence of attention deficit hyperactivity disorder (ADHD) in twins compared to their singleton siblings, however the ADHD symptoms correlated strongly with speech and reading problems (Levy *et al.* 1996). On the other hand, the same study found no differences in Oppositional Defiant Disorder, Conduct Disorder or Separation Anxiety (Levy *et al.* 1996). For most adult behavioral traits and psycho-emotional symptoms, twins show means, frequencies and prevalences similar to those shown by singletons (e.g., Kendler *et al.* 1995), although not all studies agree. A Danish register-based study by Klaning *et al.* (1996) found that mental illnesses were slightly more common in twins than in singletons, whereas another Danish register-based study found that twins had a reduced risk of suicide compared to singletons (Tomassini *et al.* 2003). Confirmation of the reported differences and similarities between twins and singletons is still relatively limited.

The notion that twinship constitutes an altered developmental context is widely accepted. Firstly, the presence of twins has a great influence on family relationships and family dynamics (Goshen-Gottstein 1980, Harvey & Bryan 1991, Lytton 1980, Sandbank 1988, Savic 1980). Also the early mother-child relationship is suggested to be different in twin families compared to that in singleton families (Moilanen *et al.* 2000, Robin *et al.* 1988, Tourrette *et al.* 1989). Secondly, the presence of two infants with the same developmental needs and tasks is considered to profoundly alter a children's usual developmental environment. Even though twins are not fundamentally different from non-twins, the specific characteristics of twinship are thought to influence the psychological and social development of twins (Ainslie 1985, Garel *et al.* 2004).

Differences in family environment specific to twins are often subjected to the greater physical and psychological stresses associated with taking care of two infants simultaneously (Ainslie 1985, Harvey & Bryan 1991, Robin *et al.* 1991). Already the twin pregnancy is an event which brings considerable physical, emotional and social change. The feelings of mothers expecting twins are mixed. On the one hand, they are filled with the joy and excitement of expecting twins, but at the same time they are anxious and worried about the well-being of their infants and for their own ability to cope and take care of the two infants at a same time (Alin Åkerman 1987, Neifert & Thorpe 1990, van der Zalm 1995). After birth, parents of twins report more psychological distress than parents of singletons, and feelings of exhaustion, anxiety and depression are relatively common (Goshen-Gottstein 1980, Griffith *et al.* 2005, Robin *et al.* 1991, Ross *et al.* 2005, Thorpe *et al.* 1991). Some studies have reported that families with twins experience a significantly higher incidence of child abuse and neglect than those with single births (Nelson & Martin 1985, Robarge *et al.* 1982, Groothuis *et al.* 1982).

Developmentalists with diverse theoretical orientations have acknowledged that one of the most important social-emotional tasks of the first year of life is to establish one-on-one interaction to build up infant-caregiver attachment. Additionally it has been suggested that a mother can form a successful and intimate relationship only with one baby at a time. Thus, parents of twins are often anticipated to face more difficulties in developing an attachment relationship with their twins (Abbink *et al.* 1982, Bryan 2003, Garel & Blondel 1992). In twin families the dyadic parent-child interaction is often viewed as a triadic situation in which the twin children form "the basic dyad" (Robin *et al.* 1988, Sandbank 1999, Tourrette *et al.* 1989). As a result, parents may be attached to the twin dyad or alternatively parents may bond with one infant at the expense of the other. Sometimes, when twins differ in their health and maturity, mothers seem to develop a preference for one twin over the other. In one study mothers tended to prefer twin that had arrived home first, i.e. the infant with fewer medical complications (Goldberg *et al.* 1986, Minde *et al.* 1990). Another study found that mothers generally preferred the weaker child (Field *et al.* 1982). The extended hospitalization of one of the twin infants has been found to disturb the parent-child bonding, which may have long-term consequences on development and attachment relationships (Minde *et al.* 1990). Hay and O'Brien (1987) found that twins who were discharged later from hospital had higher scores on depression and maladaptive behavior at school age. However, several studies of attachment relationships in infants have suggested that twins establish secure attachment in the same proportions as singletons (Goldberg *et al.* 1986, Moilanen *et al.*

2000, Vandell *et al.* 1988), and the potential for poor mother-child relationships in twins might have been somewhat overestimated.

Several studies indicate that parents of twins are more likely to have feelings of anxiety and ambivalence about their rearing practices and sharing their parental attention between the children (Dibble & Cohen 1981, Goshen-Gottstein, 1980, Robin *et al.* 1988). Mothers of twins spend significantly more of their time on infant-related activities compared to singleton mothers, but have less time to spend with each child (Goshen-Gottstein 1980, Holditch-Davis *et al.* 1999). Sometimes parents have come to the solution to treat one twin as the mother's twin and the other as the father's twin in order to provide individual attention for each child and to ease the burden of taking care of two infants at the same time. Thus, the father may become increasingly responsible for looking after one child while mother takes more care of the other (Moilanen & Pennanen 1997, Robin *et al.* 1996). Several other studies have also reported increased paternal involvement in parenting twins (Ainslie 1985, Holditch-Davis *et al.* 1999, Lytton 1980, Lytton *et al.* 1977). However, the implications of this shared parental attention has not been studied.

By necessity rather than by choice some degree of parental disregard is inevitable in twin families compared to singleton families. The triadic situation in twin families offers fewer opportunities for dyadic communication on an individual basis between a parent and a child (Savic 1980, Tomassello *et al.* 1986). Verbal communications between twin children and parents have been found to be less frequent and shorter (Holditch-Davis *et al.* 1999, Lytton 1980) and sustained joint attention has been observed less frequently than in singleton families (Clark & Dickman 1984, Tomassello *et al.* 1986). It seems also that the demonstrations of affections are less frequent in twin families (Holditch-Davis *et al.* 1999, Lytton 1980, Ostfeld *et al.* 2001).

Some parents are overly sensitive to the problem of labeling their twins and they try to avoid showing preference (Abbink *et al.* 1982, Holditch-Davis *et al.* 1999, Minde *et al.* 1990). This often leads to extremely similar treatment of twin children (Loehlin & Nichols 1976, Robin *et al.* 1994). In the study of Koch (1966) twins were more likely to view their parents as being impartial and not favoring one child over the other than other school-aged siblings. Although, impartiality and equal treatment of twins can generally be considered as a positive feature, parents need to differentiate between their twin children in order to relate to them as distinct individuals (Robin *et al.* 1988, van der Zalm 1995). Whereas some parents seem to emphasize their twins' similarities, especially in MZ twins (Kendler *et al.* 1994, Robin *et al.* 1988), other parents seem to exaggerate distinguishing features and behavioral characteristics of their twins, sometimes strictly based on the basis of their own differing expectations (Carey 1986, Goshen-Gottstein 1980, Neale & Stevenson 1989). Although emphasizing different characteristics may serve as a means of individual twin's identity formation, the problem with labeling is that the child tends to conform to the label whether it is just or not.

Tourrette *et al.* (1989) suggested that mothers of twins could be divided into two groups: *differentiation-oriented* and *twinship-oriented*. Differentiation-oriented mothers actively tried to establish an individualized relationship with each child and they emphasized differentiation in their rearing practices. Twinship-oriented mothers instead were commonly attracted by the twinship and they rather enhanced their children's similarity and treated their twins as a dyad. Mothers with higher SES and more education

were more differentiation-oriented compared to mothers with lower SES and less education, who were more often twinship-oriented. Twins' zygosity was also found to reflect strongly whether twins were treated alike or separated deliberately, as MZ twins were more likely to receive twinship-oriented treatment. Ainslie (1985) found that parents' tendencies to idealize twinship were highly dependent on their socio-economic background. Similar findings were reported also by Zazzo (1984), who found that parents of lower socio-economic groups tended to encourage "twinnes" by naming, dressing and referencing twins more similarly than did parents with higher socio-economic background.

Development of twins, like all humans, occurs not in isolation but within a network of influences operating on many levels. A variety of personal, interpersonal, and contextual factors operate separately and together and shape the individual life course (e.g. Bronfenbrenner & Ceci 1994). The environment can either enhance or diminish the alternative developmental context of twins opposed to that of singletons. Twins generally create more interest and attention than single-born children. Cultural attitudes and predispositions towards twins are still relatively stereotypical, and the tendency is that environment recognizes twins as a unit and expects their appearance, behavior and treatment to be very similar (Fiegelson 1983, Leonard 1961, Stewart 2000). This is especially true for monozygotic twins (Koch 1966). Some studies have suggested that the stereotyping may even increase as twins move into adolescence (Hay 1999). Cultural attitudes and expectations not only emphasize the unique social status of twins but also that of their parents (Dibble & Cohen 1981). The special attention that twins and their parents receive may increase the parents' desire to preserve their twins' similarity by treating and dressing them alike, and it may also increase the twins' desire to maintain their relationship as a twinship (Ainslie 1985, Schave & Ciriello 1983).

The co-twin relationship, the constant presence of a same-aged sibling during the development years, is the most frequently cited feature that distinguishes twins from singletons. Whereas naturalistic observations among singletons indicate that siblings tend to adopt hierarchical roles, with older siblings serving as role models for the younger ones (e.g., Boer & Dunn 1992), sibling relationships in twin families are in many ways more intricate. Sibling bonds in general have significant and powerful influences in most people's lives because of the span of time they encompass and the intensity of involvement that characterizes them (e.g., Brody 1998). The relationship between twins is often considered to be more intense and pervasive than that between singleton siblings (Adelman & Siemon 1986, Siemon 1980, Vandell, 1990). Growing up with a same-aged sibling creates a challenging developmental environment that can be developmentally fruitful and comforting. On the other hand this environment may not be similarly growth promoting if the primary role model and object of identification is the same-aged co-twin rather than the parents or older siblings or peers. Some studies have reported more sociability problems, withdrawal and introversion in twins compared to singletons (Clark & Dickman 1984, DiLalla & Caraway 2004, Zazzo 1960) and attached these differences to twinship. It has often been suggested that whereas adolescent singletons have a dyadic problem to resolve, the problem of twins is triadic (Fiegelson 1983, Hay 1999, Siemon 1980). Twins have to gain successful separation-individuation not only from their parents but also from their co-twin.

Most of the previous studies have approached the twinship on the basis of a psychopathological orientation and only few studies have suggested more adaptive hypothesis. The pioneering study of Helen Koch (1966) found that twins, especially female twins, were more popular and socially favored by their classmates. Recently Pulkkinen and her colleagues (2003) reported a rather high degree of adaptivity in twins' social development and adjustment, suggesting that pre-adolescent twins exceeded their singleton classmates in developing socially active and adaptive behaviors. This was especially true for twin boys, who scored higher in popularity and interactions with other children compared to singleton boys. These findings are quite contrary to the vulnerability hypothesis and suggest that twinship may also create an adaptive developmental context for psycho-emotional and social growth (Pulkkinen *et al.* 2003).

2.2 Studies of the co-twin relationship

The literature on twins, especially the popular literature, has widely depicted the richness, special closeness and unique nature of the co-twin relationship. A good many popular and scientific publications and papers on the co-twin relationship have appeared and been reviewed (e.g., Case 1996, Segal 1999, Wright 1997). Academic research on twin relationships generally falls into one of four different theoretical traditions or perspectives: psychoanalytic, behavioral-genetic, social-genetic or evolutionary psychological (Segal *et al.* 2003). The psychoanalytic or psychodynamic perspective has commonly concentrated on questions of identity formation and developmental issues such as the separation-individuation process in twins. Behavioral-genetic studies have been mainly concerned with finding out whether co-twin contact is associated with twins' similarities in different behavioral traits, whereas social-genetic research has investigated the effects of genes on social behaviors and organization. The evolutionary psychology approach has been interested in studying the co-twin relationship in the context of psychological and physical attributes of natural selection, and it has begun to explore the issues involved in promoting the survival and reproduction of the genetic inheritance of one's own genes.

Studies of different types of twins have generally indicated that the relationship between MZ co-twins is closer than that between DZ co-twins (Burlingham 1945, Fischbein *et al.* 1990, Koch 1966, LaBuda *et al.* 1997, Sandbank 1999). Several studies have presented evidence that this pattern continues into adolescence (Alin Åkerman & Suurvee 2003, Rose 2002) and may even increase towards late adulthood (Neyer 2002a). Studies done by Segal and her colleagues have found that social closeness, affiliation and altruism are more common in MZ twins than in DZ twins, as well as greater success and cooperation in completing joint task (Segal 2002, Segal & Hershberger 1999). Foy *et al.* (2001) did not find any differences between MZ and DZ twins in their level of intimacy, but MZ twins were more likely to name each other as their closest friend compared to DZ twins. Additionally they found that twins who chose each other as their closest friends reported higher levels of intimacy with their co-twin and that these twins were more likely to be MZs. Studies of older twins (mean age 70) by Neyer (2002b) and his

colleagues (Neyer *et al.* 1999) have demonstrated higher levels of intimacy, dependence, attachment security, relationship satisfaction and support within MZ than DZ twin pairs.

2.2.1 Development of the co-twin relationship

The physical and emotional closeness of co-twins is often assumed to be more intense and constant than the relationship between one twin and his/her parent(s) or other siblings (Sandbank 1988). The development of a close and interconnected relationship in twins is usually attributed to the simultaneous and permanent presence of a same-aged sibling, (Siemon 1980). The development of a close co-twin relationship has also been viewed as a consequence of parental behavior and attitudes towards twinship (Dibble & Cohen 1981, Leonard 1961, Stewart 2002). Parents create the environmental framework for the co-twin relationship by enhancing or inhibiting the development of individuality in their twins in a variety of ways, e.g. emphasizing their similarity by dressing and treating twins alike. This may lead to co-twins' special closeness, enhance the inter-twin identification and sense of belonging to one another (Allen *et al.* 1976, Dibble & Cohen 1981, Schave & Ciriello 1983). Some twins may also suffer from the special attention and expectations attached to the twinship. These twins may deliberately choose to be exact opposites by exhibiting opposite extremes of behaviors and by putting great emphasis on their differences. The relationship between them is often characterized by feelings of competition, jealousy and even hatred (Alin Åkerman 2003, Hay 1999, Schave & Ciriello 1983). Yet, instead of being symptoms of an actual negative relationship, these feelings and behaviors may be means of establishing and reinforcing co-twins' individual identity.

Some studies have associated the development of a close and intimate co-twin relationship with limited parenting and the lack of sufficient and satisfying parent-child bonding (Leonard 1961, Robin *et al.* 1988, Schave & Ciriello 1983), and co-twin relationship is seen as a substitute for a disappointing and frustrating relationship with the parents (Arlow 1960, Joseph 1961). Schave & Ciriello (1983) found that a significant determinant of the co-twin relationship was the nature of the interaction between twins and their parents. Inadequate parenting, which created a highly interdependent relationship in co-twins, was characterized by parents' inability to interact with and to have physical and emotional contact with their children. As a result, the co-twin relationship became the most important source of comfort and support. Some twins clearly stated that their co-twin was more important to them than their mother or father. Unexpected in the study by Schave and Ciriello (1983) was that mothers often allowed the twinship to become the primary attachment relationship. A study of attachment relationships by Goldberg *et al.* (1986), found that twins from less adaptive mother-child dyads were more often securely attached compared to singletons from similar dyads. The authors suggested that the co-twin relationship and the physical presence of the co-twin are likely to compensate for less optimal parental care. This finding is also supported by other studies that have found that among infant twins co-twins provide consolation and a buffer against strong reactions to separations from the mother or in situations where parents are absent (Clark & Dickman 1984, Gottfried *et al.* 1994).

More recently, it has been suggested that genetic constitution may play a role in the development of the co-twin relationship, as attachment and interaction patterns have found to be somewhat different in MZ and DZ twin dyads. Neyer (2002a) proposed that the co-twin relationship can be understood in the framework of gene-environment correlation effects, namely passive, active and evocative effect. The co-twin relationship is predetermined for both MZ and DZ twins at birth (passive effect). Over the life course MZ twins are more likely than DZ twins to choose their co-twin as a close relationship partner (active effect), and simultaneously they are more likely to be chosen by their co-twin (evocative effect). According to Neyer, due to their genetic similarity, MZ twins are more likely to seek out similar environments, whereas DZ twins are more likely to search for different environments as they grow older, likely owing to a decrease of co-twin contact and to the lower intensity of the co-twin relationship. A similar perspective has also been adopted in the evolutionary psychological approach, which suggests that altruistic acts, social closeness and affiliative feelings toward close genetic relatives may be interpreted in terms of genetic relatedness (Segal *et al.* 2003).

2.2.2 The co-twin relationship and twins' social adaptation

It is commonly assumed that social networks and the diversity of peer relationships outside the family are crucial for psycho-social development. This assumption has received support from various studies of the influences of peer relationships (e.g., Bukowski *et al.* 1996). A number of studies of co-twin relationships and twins' social interactions have revealed that twins spend a substantial amount of their leisure time together and they often share their friends and leisure-time activities (Loehlin & Nichols 1976, Preedy 1999, Rose 2002, Vandenberg 1984).

Deficiencies in twins' social adaptation are often seen as a consequence of the intimate co-twin relationship, the "twinning bond", which is considered to isolate twins from outside world and to discourage the formation of other relationships outside the twinship (Adelman & Siemon 1986, Burlingham 1963, Zazzo 1960, 1976, 1984). Some researchers have associated isolating behaviors observed in childhood (e.g., twins' more common solitary play and withdrawal from social activities with others) with the co-twin relationship (Clark & Dickman 1984, Cohen *et al.* 1977, Lytton 1980, Savic 1980, Vandell *et al.* 1988). A study by Alin Åkerman and Suurvee (2003) found that adolescent female twins' ability to relate to peers seemed to be poorer compared to that of twin males, which could be partly explained by their more interlaced and symbiotic relationships. Similarly, twins' tendency to marry later has been suggested to be a consequence of the intimate co-twin relationship (Zazzo 1960), whereas other studies have not found evidence that twins would differ from singletons in their adult relationships, e.g. marital status or number of years married (Lange & Fischbein 1992, Pearlman 1990).

Whereas some researchers predict problems arising from the co-twin relationship, others suggest that it may in fact facilitate the formation of close relationships with others. Koch (1966) found that the closeness between twins did not affect their friendships with other children and that MZ girls were particularly popular at school.

Similar findings for older twins (16-73 years of age) were reported by Foy *et al.* (2001), who did not find any association between twins' level of intimacy and their propensity to form of close and intimate relationships outside the twinship. Foy *et al.* (2001) indicated that closeness and intimacy in the co-twin relationship predicted more intimate relationships with close others. Zahn-Waxler *et al.* (1992) suggested that in early childhood the co-twin relationship may provide a unique context for experiencing other persons' emotions and may thus enhance patterns of empathy, especially in DZ twins. The more cooperative and prosocial DZ twins were with each other, the more likely they were to express prosocial and empathic concerns for others outside the twinship. However, in MZ twins the effect was the opposite: the more prosocial MZ twins were towards each other, the less likely they were to show empathic concerns to others outside the twinship. A more recent population-based study found that twins received higher scores in socially adaptive behaviors than singletons (Pulkkinen *et al.* 2003). The authors concluded that the co-twin relationship offers a rather positive context for social-emotional development by providing opportunities for shaping, imitating and practicing social skills.

2.2.3 The co-twin relationship in the context of personality and identity formation

Identity development is traditionally conceptualized as a process that begins at birth and is affected by parenting and socio-cultural environment (e.g., Erikson 1950, 1968, Mahler *et al.* 1975, Marcia 1980). Previous clinical and case studies have suggested that the basic problem that twins encounter as a group is the special difficulty in developing and establishing a sense of identity and an adequate self-image (Joseph 1961, Orr 1941, Zazzo 1960). Difficulties in identity formation, personality development and self-esteem have often been seen to follow from the close and intimate co-twin relationship, which may enhance and provide means for the fusion of object representation and self-representations (Alin Åkerman 2003, Burlingham 1952, Fiegelson 1983, Glenn 1966, Joseph & Tabor 1961, Leonard 1961, Miliora 2003, Orr 1941). Evidence to support this view has sometimes been cited from studies of the way that twins refer to themselves, e.g. usage of personal pronouns (Bernabei & Levi 1976, Malmström & Silva 1986, Zazzo 1960) or how they define themselves through the co-twin relationship. In a study of Alin Åkerman and Suurvee (2003), MZ females seemed to be especially vulnerable to identity problems, whereas DZ twins, who were treated as more individuals, were able to develop a more positive identity in adolescence.

In an interview-based study, Macdonald (2002) found that twins had three distinct ways of describing themselves within their co-twin relationship. First, twins may define themselves *as two separate* individuals with own separate psychological boundaries. Secondly, twins may share a psychological boundary, and a sense of self is created in relation to the co-twin, i.e. *two as if one*. These twins are also likely to relate to others as a unit. The third form of relating Macdonald described as a false separation in which the boundary is shared but the emphasis is on *only one twin (either/or)*. Within this category identity is polarized and twins exhibit different and competing qualities. In general, twins

may relate to each other in one or all of these different ways. Problems occur if the patterns of relating are too rigid or extreme or if twins are not able to redefine their relationship as changes in environmental situations or developmental phase require.

Identity may, however, express itself very differently in twins and encompass both positive and negative qualities. Schave and Ciriello (1983) interviewed 20 sets of young adult twins for their qualitative study of identity and intimacy in twins. They found six distinct identity patterns, which they labeled as *unit*, *interdependent*, *split*, *competitive*, *sibling attachment* and *idealized*. According to Schave and Ciriello, the six patterns of twinship represent a continuum of psychological closeness and interaction, ranging from an all-pervasive closeness including merging identities to close attachments and caring feelings that allow individuality to develop. All twins with these different identity patterns felt a certain connectedness and closeness, "a twinning bond," with their co-twin. However, the relationship with twins exhibiting *unit identity* or *interdependent identity* was more intense and pervasive than in other identity groups. Twins with unit identity were unable to separate psychologically, and they referred to this situation as one of conflict and ambivalence. In contrast, twins with interdependent identity had an equally close relationship, but without anxiety or ambivalence. In the other four groups of *idealized*, *split*, *competitive* and *sibling attachment identity*, the twinning bond was more functional, serving the twins' daily activities as a team and bringing security and mutual trust.

The concept of twinship was introduced by Winestine (1969) in his study of the psychological individuation of twins. Winestine calculated a *twinship score* to estimate the level of individuation in twins with indicators, such as self-image as a twin, reactions to separation from the co-twin, differences in personality, and interest evolving as a reaction to co-twin rather than from positive individual identification, and ability to establish object relationships with peers and view oneself as a discrete object of choice for peers apart from the co-twin. Winestine (1969) found that different dimensions of twinship score were highly reciprocal and dependent on both members of the twin dyad. One twin tended to respond to the action of the other by the same kind of action to a relatively similar degree. According to Winestine, a high twinship score doesn't necessarily imply pathological outcomes, but problems are more likely to occur if the mother-child relationship is insufficient to prevent the development of excessive mutual dependence or identity fusion in twins.

The split and polarized roles or opposing personality characteristics of co-twins are often considered as an indication of complementarity (Ainslie 1985, Schave & Ciriello 1983). Complementarity occurs when the actions of the two partners are not the same but complement each other in a mutually suitable way. Complementarity is also implicit in the frequently described dominance-submissiveness in twins, which can be manifested as dominance or submissiveness in physical, psychological and social areas of life (Koch 1966, Moilanen 1987, Tienari 1966). The submissiveness in one area is often compensated by equality or dominance in another area (Ebeling *et al.* 2003, Moilanen 1987). Alin Åkerman and Suurvee (2003) found similar complementarity in preterm twin girls. In these pairs one twin girl tended to be more active and independent, taking a protective role, while the other sister was more passive, dependent and the one to be protected. Several authors have pointed out that the existence of identity polarization or complementarity in different features, such as dominance-submissiveness or opposing

roles (e.g. active-passive, strong-weak) may help twins to create a well-functioning unit and diminish competition between them (Ainslie 1985, Moilanen & Ebeling 1998). On the other hand, if the polarization of roles is too rigid or somewhat forced, this may lead to fewer opportunities to show one's real abilities and to the suppression of individual needs. Various studies have indicated that the most submissive twins often suffer from psycho-somatic symptoms and depressiveness, whereas most dominant twins are more likely to have nervous symptoms (Ebeling *et al.* 2003, Moilanen 1987). Twins who share dominance-submissiveness in different areas of life seem to be in the most favorable position.

2.2.4 The co-twin relationship and separation-individuation in twins

Adolescence is the time when separation is most likely to threaten the twinship. In the separation-individuation process attachment relationships, internal self-awareness, identity and self-esteem are changed and re-established. Compared to singletons, twins have been suggested to have a double task: twins have to gain autonomy not only from their parents, but also from each other (Adelman & Siemon 1986, Leonard 1961). The extent of differentiation and the degree of difficulty experienced in separation has been suggested to depend on the nature of the relationship co-twins have had with each other as well as the feeling they have about being twins (Schave & Ciriello 1983, Siemon 1980). The intimacy and intensity of the interaction between co-twins may actually accelerate the separation from the mother only to be replaced by a prolonged symbiosis between the twins, with the consequence that separation-individuation may be delayed (Leonard 1961). This may manifest itself in later developmental periods as retarded maturation and higher levels of dependence (Ainslie 1985, Leonard 1961). In the study of Ainslie (1985) co-twins who often had bouts of considerable anxiety at the thought of losing each other or being separated also exhibited pronounced interdependence on each other. He argued that this pronounced strong separation anxiety presumably encouraged the maintenance of greater interdependence and inability to achieve successful separation. Another study of Schave and Ciriello (1983) found that twins with interdependent identity did not find it necessary to separate psychologically. For these co-twins separation-individuation from each other was not as important as the shared relationship between them. The satisfaction with their relationship was more significant than any effort to strive for greater achievements.

As twins grow older requirements to function as two separate individuals increase. This may cause insecurity and ambivalence in twins who had a close and intense relationship. Schave and Ciriello (1983) found that twins with a very close and intimate relationship were far more likely to be uneasy in these new situations and these twins usually tried to function in an interrelated manner, even if it was inappropriate. The interaction between these co-twins was a crucial determinant of their existence and they had relied on each others' companionship and the security of the twin relationship throughout childhood and adolescence. Siemon (1980) has suggested that no psychological threat exists as long as the twins can function as a unit. The subjective experience of twinship and expectations of behaving as a dyad become an emotional issue in the course of development. When

self is shared, separation can bring fears of loss of self (Ainslie 1985). Severity of the reaction to separation has been suggested to depend on age at which separation occurs, degree of inter-twin identification, advantages seen in a twinship as well as what the twinship has symbolized (Siemon 1980). Depression, anxiety and grief can be obvious clinical symptoms of separation. Similarly, a prolonged struggle between separation and individuation is seen as a handicap in the formation of other relationships. If the co-twin relationship serves as a defense against insecurity and a fragile sense of self, the clinging relationship may be exchanged for another in which an individual can once more be part of a unit. Dependence between twin siblings is often seen as a reaction to separation, and twins may sustain a pattern of duality as a way of denying separation.

2.3 Theoretical perspectives

The special bond or connectedness between twin siblings has been described widely in twin literature and called by various names (e.g., twinning bond, twinning effect, twinship). Despite the enormous literature devoted to twins, only a few attempts have been made to place the co-twin relationship in a coherent theoretical framework. The research tradition of co-twin relationships is still lacking uniform conceptualizations of the characteristics of the co-twin relationship. Although numerous studies and equally numerous definitions of the co-twin relationship emphasize different aspects of the relationship, they share common elements, namely those of attributes, concepts and descriptions, of twinship as a dyadic relationship in which proximity and intimacy to a co-twin is sought and maintained. Psychoanalytic and attachment theories of object relationships have laid the ground for understanding these affective dyadic interactions, especially in the mother-infant relationships.

The terms “interdependency,” “inter-twin dependency” and “co-twin dependence” are often used to characterize the co-twin relationship. Compared to others, such as twinning bond, closeness, intimacy or connectedness, co-twin dependence has received more often negative connotations (Lytton 1980). Several authors have suggested that there is a strong interconnection between levels of co-twin dependence and strong inter-twin identity consolidation (Alin Åkerman & Suurvee 2003, Ainslie 1985, MacDonald 2002). Dependence in twin siblings is usually interpreted in rather psychopathological terms, indicating maladjustment and psycho-emotional vulnerability (Joseph & Tabor 1961). Dependent twins are anticipated to have more difficulties in identity formation and psychosocial development (Fiegelson 1983, Joseph & Tabor 1961, Leonard 1961), however relatively little attention has been paid to associations of dependence with twins’ psycho-emotional or social functioning.

The lack of previous studies of co-twin dependence in population-based samples is evident. Most of the few studies of dependence with large twin samples are based on parental reports of dependence. In a study of Fischbein *et al.* (1990) parents of 70 same-sex twin pairs (age 11-12 years) reported contextual and zygosity variations in dependence. They also found that MZ twins were more often dependent on each other than DZ twins were. The difference in dependence seemed to increase between the twin types with age. According to these reports, dependence was more common among girls,

especially MZ girls, who spent also more of their leisure time together compared to MZ boys, or among DZ boys and girls. Moilanen (1988) followed 497 twin individuals from birth into late adolescence (age 12-20). Twins and their parents answered questions concerning co-twin relationship and co-twin dependence. The focus of the study was, however, on the late effects of perinatal morbidity and of psychosomatic and depressive symptoms. Co-twin dependence was analyzed in relation to these factors, but not as an independent factor. The findings of Moilanen (1988) indicated that there was a tendency for co-twin dependent twins to score higher on psychosomatic symptoms and depressiveness than co-twin independent twins or twins in an intermediate position. Moreover, dependent twins were significantly more likely to report feelings of inferiority and they were also more likely to be the submissive co-twin in the twin dyad. A follow-up study of that same sample at age of 22-30 (n= 419) included twins' self-reports of co-twin dependence (Trias *et al.* unpublished). In the follow-up twins reported retrospectively their dependence on their co-twin before school age and at school age as well as currently as young adults. Dependency was more common among females and in MZ twins, and appeared to weaken in relation to age. In an interview study of 108 older twins, at a mean age of 70 years, Neyer (2002b) found that MZ twins were more dependent on and more securely attached to their co-twin compared to DZ twins. The authors also found that whereas attachment security was only moderately related to contact frequency in DZ twins and negligibly in MZs, dependency in contrast was positively correlated with the dyadic contact. Neyer (2002b) interpreted this to illustrate how dependency as a relationship quality, compared to attachment, is more linked to social exchanges and instrumental needs such as emotional support.

Relatively few studies have ventured to examine the positive associations or implications of co-twin dependence. A qualitative study of Schave & Ciriello (1983) with 20 sets of adult twins indicated that twins with an interdependent identity pattern were more likely to choose each other as the closest person and the main attachment figure in their lives. Similar results were found by Neyer (2002b) for twins at old age. In the study by Schave and Ciriello (1983), twins with an *interdependent identity* and twins with a *unit identity* reported equally close relationships and equally intense and pervasive bonding between the twins, but interdependent twins did not report similar feelings of anxiety, conflict or ambivalence as twins with unit identity. In interdependent twins the twinship experience and interrelatedness were gratifying, providing the most trusted friendship and the best of source of emotional support. Thus, dependence in these twins could be conceptualized more optimistically, entailing also positive qualities, such as emotional sustenance and reliance as well as feelings of closeness, security and belonging, i.e. features that are more commonly associated with attachment relationships.

In the following, two theoretical and conceptual approaches to co-twin dependence, namely attachment and dependency (or dependence), are examined briefly. Both approaches share the same theoretical basis, which is generally found in psychoanalytic theories of object relations, social learning theories and the ethological theory of attachment (Bornstein 1992, 1993). Some authors have suggested that the distinction between attachment and dependency can be made only conceptually, since studies of both attachment and dependency measure similar patterns of social behaviors and these two dimensions are likely to be related within individuals (Lytton 1980, Neyer 2002b).

2.3.1 Attachment

Attachment theory is based on the view that individuals possess innate attachment behavioral systems. Every human being enters the world dependent on one or more individuals, and these individuals are likely to become *attachment figures*. Attachment is usually described as a strong and enduring bond a “lasting psychological connectedness between human beings” (Bowlby 1969). Ainsworth (1969, 1989) and Bartholomew (1990) additionally stressed that the *affect* is crucial in attachment relationships. Thus theory suggests that the residue of prior attachment relationships takes the form of internal working models of self, relationship partners and later dyadic relationships. Traditionally, research on attachment relationships has emphasized the very early attachments formed between infants and their caregivers. During the past decades attachment theory has evolved to encompass adult attachment processes, thus providing insights into social and emotional development and interpersonal relationships across the lifespan among increasingly older groups, including adolescents, adults and older adults (Bartholomew 1990, Cookman 2005, Hazan & Shaver 1987).

One important aspect of attachment theory is that the attachment figure can be identified as a specific person. According to Ainsworth (1989) attachment figures are never wholly interchangeable with or replaceable by others, even though there are other such figures with whom one is also attached. Usually the attachments are formed to a few persons only, and these *selective attachments* appear to be derived from social interactions with the attachment figures. The earliest attachment relationships are usually formed in infancy, where mother is viewed as the primary attachment figure (Ainsworth 1969, Main *et al.* 1985). However, a father or sibling can have the same type of attachment with the infant at the same time. This relates to adults having more than one primary attachment, such as to their spouse, children and friends.

Four distinct components of attachment are usually described: secure base, safe haven, proximity seeking and separation protest (Bowlby 1969, 1973, Ainsworth *et al.* 1978). These patterns are observable in the behavior of an attached person in relation to the object of attachment. The *secure base* refers to a possibility to trust in the availability and proximity of the significant other when support or comfort is needed. *Safe haven* implies the possibility to turn to the other for comfort and support in times of distress. *Proximity-seeking* and *separation protest* represent behavioral patterns through which the physical and emotional proximity to the attachment figure are maintained, e.g. tendency to approach, stay near, and make contact with the other and correspondingly to resist separation and to be distressed when it occurs.

For an infant, attachment involves seeking to be close a significant other and to promote exploration of the world from a secure base provided by attachment figure (Bowlby 1969, Ainsworth *et al.* 1978). As a child reaches adolescence, the attachment to the parents or caregiver is believed to persist, although relationships involving peers as significant attachment figures become increasingly important, supplementing those established in childhood. Attachment bonds between parents and adolescents are “treated by many adolescents more like ties that restrain than like ties that anchor and secure, and a key task of adolescence is to develop autonomy so as no longer to need to rely (as much) on parents' support when making one's way through the world” (Allen & Land

1999). At the same time, however, the secure base provided by parents remains indispensable for optimal functioning and mental health (Bowlby 1988).

Attachment relationships in adults are suggested to be more reciprocal and symmetric than in childhood (Simpson & Rholes 1998). In adulthood attachment relationships are formed in interpersonal relationships and social networks, and attachment figures in adults can be mentors, close friends, romantic partners, their own parents and their own children. The attachment patterns to these different persons vary and serve multiple functions. Individuals develop networks of preferred relationships that refer to relationships in which individuals regularly expect to find opportunities for companionable and/or supportive interactions. Adult attachments have similar functions as early attachments. During stress, individuals seek contact with their attachment figures: comfort increases and anxiety decreases in the presence of this figure, and separation or threat of separation from the attachment figure will cause discomfort and anxiety only when this figure is inexplicably inaccessible (Weiss 1991). There are several instruments for measuring adult attachment, most of which work with a typology of three or four attachment styles (e.g., Bartholomew & Horowitz 1991, Hazan & Shaver 1987). Bartholomew and Horowitz (Bartholomew 1990, Bartholomew & Horowitz 1991) conceptualized adult attachment styles as combinations of the positive or negative working models of self and others. The model of self is associated with dependence or non-dependence, dependent on whether self-esteem has been internalized, not requiring external validation or acceptance of others. The model of others is associated with the degree of avoidance or non-avoidance of close relationships and contact with others. A *securely attached* person is low in dependency and low in avoidance of close relationships. Such a person is comfortable with intimacy and autonomy. A *preoccupied attachment* style (low avoidance/ high dependence) may be expressed as overt dependency on others and a tendency to seek continuously for acceptance and validation from others. The safety, security and self-worth of these persons are utterly dependent on others. A person with a *fearful attachment* style (high avoidance/ high dependence) desires emotional intimacy, but finds it difficult to trust or be dependent on others because of fear of rejection. A *dismissing attachment* style (high avoidance/low dependence) is characterized by the tendency to deny the importance of close relationships and tendency to emphasize the importance of independence and self-reliance.

Attachment research has shown that attachment styles are associated with the development of psychopathology (e.g., Atkinson & Zucker 1997). Secure attachment to significant others confers a form of emotional resilience that promotes emotional well-being and social competence (Kobak & Sceery 1988). Several authors have reported that the securely attached are significantly less likely than the insecurely attached to be negatively influenced by anxiety, hostility, depression, loneliness, and symptoms of illness (Irons & Gilbert 2005, Kidd & Sheffield 2005). Insecure attachment is not as such an indicative of psychopathology; however it may serve as a significant risk factor for psychological and social dysfunction (Rutter 1995, Sroufe *et al.* 1999). Attachment classifications made at infancy have also been found to be associated with numerous parameters in adolescence, such as emotional maturity, peer relationships and academic performance (Main 1996, Carlson & Sroufe 1995, Weinfield *et al.* 1997), suggesting that attachment relationships have significant influences later in life. The common view is that

close and intimate attachment relationships provide an important foundation for later development and that a secure attachment may serve as a protective factor against the negative impact of various adversities and risk factors.

2.3.2 Dependency

The construct of interpersonal dependency has been of increasing interest to researchers and clinicians because of its importance for close relationship dynamics and individual well-being. More than 500 empirical studies of interpersonal dependency and of the dependent personality have been published since 1950 (Bornstein 1993). Similarly, several diagnostic and non-diagnostic measures have been developed for interpersonal dependency (Bornstein 1993).

Two important features are often related to dependency: the conflict related to dependency needs (i.e. needs for affection, protection, support and help) and involvement of dependency-related cognitions (Bornstein, 1992). The psychoanalytic approach to dependency assumes that individuals are conflicted by the often unconscious innate dependency needs and conscious prohibitions of expressing these needs. According to the psychodynamic approach, dependency is a function of a person's mental models of self and others. The parent-child relationship is crucial in the development of dependency. The social learning approach is based on the idea that the conflict arises from inconsistent socialization practices, which on the other hand, enhance dependency by setting requirements to obey authority figures, but on the other hand emphasize children's need to learn to be autonomous and independent. Learning theories emphasize modeling and reinforcement in the development of dependent behaviors, i.e. belief and expectations regarding rewards and punishments associated with expressing dependency needs and behavior. Based on these two theoretical approaches Bornstein (1993) has presented an integrated theoretical model of dependency as a complex set of thoughts, beliefs, feelings, and behaviors revolving around needs to associate closely with valued other people.

Even if relatively little is known about the etiology of dependency, Bornstein (1993) has concluded that from a theoretical standpoint, dependency has above all social roots and that individual differences in it can be traced to early social interactions. Assessments of the influence of the overall infant-caretaker relationship and parenting styles on later dependency have consistently shown that dependency is strongly associated with parental overprotection (e.g., Ojha & Singh 1988, Parker & Lipscombe 1980) and authoritarianism (e.g., McCranie & Bass 1984), which, according to Bornstein (1992, 1993), reinforce dependent behaviors in children and prevent the child from developing independent, autonomous behaviors. These parenting styles seem to foster and encourage representation of self as powerless and ineffectual, i.e. the belief that one is dependent on others (Bornstein 1993). Another determinant of dependency is gender. Several studies have reported that dependency is more common in females than in males (Bornstein, 1992), but when projective measures are used differences between genders are generally not found (Bornstein *et al.* 1993). Similarly, longitudinal studies of self-reported dependency in young children have found relatively little or no differences in dependency

between boys and girls (MacCoby & Jacklin 1974), but as children grow older the differences in dependence seem to increase along with increasing age (e.g., Golightly *et al.* 1970, Kagan & Moss 1960). Bornstein (1992, 1993) has interpreted this change in dependency and differences between genders in dependency as an indication of sex-role socialization. Boys are more likely to be discouraged from exhibiting their dependency needs and dependent behavior openly, whereas in girls this behavior is more acceptable. Similarly in adulthood, even though males and females have similar innate dependency needs, males are less likely to acknowledge these needs in self-report measures.

Although some degree of dependency is considered normal in all human relations, especially in childhood (Bornstein, 1992), excessive dependency on others is considered to undermine close relationships and threaten individual development and well-being (Bornstein 1992, 1995). Studies examining the effects of dependency on different social behaviors and well-being have found that dependent persons are usually more susceptible, yielding, help-seeking and compliant than non-dependent persons (Bornstein 1993). Dependent persons have often been characterized as showing excessive emotional reliance on others, avoidance of situations requiring independent decisions, submissiveness and lack of self-assertion. Dependency is seen as a “defensive” behavior whose purpose is to externalize responsibility for one’s actions, unwillingness to engage in independent self-directed behaviors. Additionally, dependency has often been associated with negative characteristics such as immaturity, weakness and psychological impairment (Ainsworth 1969).

Robust evidence indicates that dependency is associated with a variety of psychological, social and behavioral problems as well as psychiatric disorders. Dependency has been found to correlate positively with depression, anxiety, neuroticism, insecurity in social situations, problems with social behavior, low self-esteem and substance use disorders both in clinical and non-clinical settings (Birtchnell *et al.* 1991, Bornstein, 1993; 1993, Bornstein & Johnson 1990, Overholser 1996). The vast majority of theoretical and empirical studies have primarily concentrated on the negative aspects of dependency. However, only more recently it has been suggested that it is important to distinguish “normal” (i.e. context-and situation appropriate) dependence from “pathological” (i.e. maladaptive and inflexible) dependence. Bornstein (1998) has stressed out that the deficit view of dependency is overly narrow and unnecessarily pessimistic. Dependency has proven to be associated also with positive and adaptive qualities such as interpersonal sensitivity and more frequent and more intimate social interactions (Zuroff *et al.* 1995).

2.3.3 Attachment, dependency and co-twin dependence

Both constructs, attachment and dependency, have been applied to describe situations in which one person’s behavior relies or depends intimately upon the appearance and behavior of another or others, and the definitions of these two have often been overlapping, complementary or mutually exclusive (Gewirtz 1972). Despite the overlap between dependency and attachment, these two constructs are also quite different frames of reference. The etiology and dynamics of dependency and attachment are suggested to

differ in two critical aspects (Bornstein 1992). Firstly, the notion of an attachment figure as a “preferred and differentiated person” is a widely accepted central feature of attachment, whereas dependency has been considered to be a more generalized response tendency that is not directed to any specific individual (Ainsworth 1972, Gewirtz 1972, Livesley *et al.* 1990). Secondly, attachment behavior is manifested primarily by proximity-seeking, whereas manifestations of dependency are more often related to help-seeking behaviors. Dependency arises out of experience or concern to obtain the assistance and companionship of other people in order to meet or satisfy other needs (Bornstein 1992), and interaction with social partners is not seen as an end in itself. In contrast, attachment is seen to arise out of an inborn need to be close, proximate, and intimately involved with one who is responsive to what we are communicating and therefore more often as an end in itself.

Another discriminating feature is the associations related to these two constructs. Dependency is more often associated with psychopathological characteristics and negative developmental outcomes such as immaturity, submissiveness and helplessness, whereas attachment has been understood to refer to the more mature and enduring nature of a relationship (Ainsworth 1969, 1972). In a study of singletons and twins, Lytton (1980) found that parents preferred to see their children as attached but not dependent. During the past decades the research on attachment relationships has broadened its focus on interpersonal relationships beyond infancy and emphasized the importance of attachment relationships in the development of all human behaviors through life. Research on interpersonal dependence has continued to have a relatively narrow focus, concentrating on personality development and having strong clinical implications and associations with psychological and psychiatric vulnerability (Bornstein 1992).

Studies on co-twin dependency have their roots in the psychoanalytic tradition, and as a consequence case and clinical studies have been overrepresented. This has steered research and discussion toward on maladaptive behaviors and psychological problems that might be associated with co-twin relationship. As consequence, twin researchers have usually applied the concept of dependency (or dependence) in order to characterize the strong interconnection and interlaced behaviors between twins. Twin relationships have rarely been studied from the attachment perspective (Neyer 2002b). However, in close and emotional relationships of many sorts (e.g. romantic relationships, close friendships or sibling relationships) there may be aspects of attachment present in which the basic elements are similar: seeking proximity, using the other as a safe haven and a secure base, and providing comfort in times of stress. Similarly, the co-twin relationship can be understood in the framework of attachment relationships covering the reciprocal influences of twins on each other as well as on their parents and the relationship of both caregivers to each twin.

2.4 The Twin Method

For several decades twin studies have contributed greatly to our understanding of the genetic factors in human development and given insights into the relative contributions of genetic and environmental factors to different human characteristics and traits. Sir

Francis Galton originated the phrase “nature vs. nurture” and in 1883 went on in his book *“Inquiries into Human Faculty and its Development”* to suggest that comparing extremely similar and extremely dissimilar twin pairs might provide a mean of apportioning the contribution of nature and nurture to certain characteristics (Galton 1875, 1876).

The Classical Twin Method compares the pair-wise similarity, assessed either as intrapair correlations (for continuous traits) or as concordance rates (for binary traits), of monozygotic and dizygotic twins (Boomsma *et al.* 2002). Concordance refers to the similarity of mono- and dizygotic twin pairs, i.e. the rate of similar occurrence of a trait or disease in both twins of the dyad. While environment is considered to be equally similar in MZ and DZ twins, the genetic constitution of these twins differs: MZ twins share 100% of their genes, where as DZ twins share approximately 50% of their genes. Therefore, greater concordance for a particular trait in MZ twins than in DZ twins is taken as an evidence of the genetic contribution to the variation of the trait. Heritability (h^2) is a measure of the proportion of the phenotypic variance that is due to genetic variance. One can obtain a crude estimate of the role of heritable factors for a disorder by doubling the difference in MZ and DZ correlations for a trait.

Modern behavior genetic studies partition the population variance into additive and non-additive genetic components, as well as shared common environmental effects (C) and unique environmental effects (E) that are not shared by the co-twins (e.g., Boomsma *et al.* 2002, Plomin *et al.* 1997). Traits can be inherited via different genetic mechanisms: some traits are governed by dominant (D) genetic mechanisms and others by additive (A) genetic mechanisms. The additive genetic effects refer to the cumulative effects of several genes whose influences combine in an additive fashion to produce differences at the phenotypic or observable level in the trait in question. Twin studies, in general, assume that only one type of genetic mechanism, usually additive, is operating for a particular trait. Shared environmental factors could include, for example, parental influences that affect all siblings, the influence of the neighborhood or school, and shared peer influences. Non-shared environmental influences or exposures include, for example, illnesses or accidents, factors that only one of the co-twins experiences.

Quantitative genetic designs rely on several assumptions (e.g. Neale & Cardon 1992). First, it is assumed that MZ and DZ twins raised together experience equally similar environments and they are equally correlated in their exposure to environmental factors with etiological importance for the trait under study (EEA, equal environments assumption). The second assumption concerns random mating, which assumes that people are as likely to choose partners who are different from themselves as they are to choose partners who are similar for a particular trait. The third assumption is that there is no gene-environment correlation or gene-environment interaction. The former refers to genetic effects on individual differences in liability to exposure to particular environmental circumstances, and the effects can be manifested as passive, evocative or active (Plomin *et al.* 1977). The gene-environment interaction refers to a specific combination of genetic and environmental factors: either there are genetically influenced individual differences in the sensitivity to specific environmental features (Eaves 1984), or environmental features may control the expression of the genes (Boomsma *et al.* 2002). The underlying assumptions of the twin method have been under debate among researchers as it has long been acknowledged that both gene-environment correlation and

interaction are potentially important in understanding the dynamic mechanisms of genetic and environmental risks. Improvements in analysis, namely Structural Equation Modeling (SEM), have made it possible to take gene-environment correlation and gene-environment interaction into account by stratifying the data according to differences in environmental factors.

The potential violation of the EEA is most commonly attributed to the supposition that MZ twins may receive more similar treatment by parents, peers and others than DZ twins. However, several studies that have compared twins whose zygosity has been misdiagnosed to twins with correctly identified zygosity have provided evidence that the perceived zygosity is not likely to alter twin concordance (Kendler *et al.* 1993, Matheny *et al.* 1976, Matheny 1979, Scarr 1968). Studies of environmental exposure have often referred to the closer contact between MZ twins than between DZ twins. Higher rates of co-twin contact in MZ twins have often been anticipated to influence the degree of similarity in twins, and some studies have found an association between increased correlation and co-twin contact for such parameters as years of education, alcohol and cigarette usage, political and social opinions, and personality (Clifford *et al.* 1984, Heller *et al.* 1988, Lykken *et al.* 1990, Rose *et al.* 1990). The empirical evidence supporting this association is, however, mixed and in most of the studies the magnitude of the association between contact and similarity has been relatively small or negligible (Heath *et al.* 1989, LaBuda *et al.* 1997, Lykken *et al.* 1990, Reiss *et al.* 2001a). It has also been questioned whether co-twin contact leads to similarity or whether similarity leads to co-twin contact (Lykken *et al.* 1990, Plomin *et al.* 1997, Rose & Kaprio 1988). The crucial, yet unanswered question is whether contact frequency really tells something about the quality of co-twin relationship, or are more sophisticated measures needed that encompass not only physical contact but also psychosocial and emotional characteristics. Studies of co-twin dependence may be fruitful in this framework.

Gene-environment interaction in the etiology of alcohol use and the early onset of alcohol use is a common finding. Various moderating factors have been reported, such as religion (Koopmans *et al.* 1999), regional residency (Rose *et al.* 1999), the socio-demographic characteristics of the community of residence (Dick *et al.* 2001) and differences in parental monitoring (Maes *et al.* 1999). Similar findings have been reported for other traits. Turkheimer *et al.* (2003) found that heritability of IQ was moderated by socio-economic status. Other studies have shown how contextual factors, such as poor-good or restrictive-permissive environment, are apparently important for the processes by which genetic potentials are actualized in individual development (Bronfenbrenner & Ceci 1994, Lange 2000). However, relatively little attention has been paid to the environmental influence of interpersonal relationships and even less to the fact that each twin forms a part of the environment of his/her co-twin. Heath *et al.* (1989), who included analyses of interpersonal influences, found that genetic effects on drinking habits were significantly modified by marital status. Although family environment may be important source of individual differences, its effects are likely to be transitional and seem to decrease in importance as the individual leaves the home of origin. Similarly it has been found that the modest impact of genes in childhood seems to increase substantially as the individual enters adulthood (Plomin *et al.* 1997).

Genes do not act in isolation from the environment. Although it is important to be aware of the significant and very real contributions of genetic and constitutional factors

to the outcome of development and different traits in human behavior, it is equally crucial to examine how experiences, interactions with the environment and interpersonal relationships shape the development and behavior of an individual. Genetic potential is expressed within the settings of social experiences, and the interplay between nature and nurture is delicate. Recent findings of such an interdisciplinary effort suggest that there is no need to choose between genetic and environmental, nature and nurture. The question no longer involves a choice between heredity or environment, but of how heredity and environment interact in the development and behavior of an individual.

3 Aims of the study

This study was undertaken to assess co-twin dependence and its associations with twins' social-emotional and health-related behavior and well-being.

The specific aims were:

1. to describe co-twin dependence and its associations with twins social interactions and educational attainment in a population-based sample of twins (I)
2. to analyze differences in dependence according to zygosity and gender.
3. to assess short- and long-term effects of co-twin dependence on twins' self-reported health and mental well-being (II)
4. to assess the influence of co-twin dependence on drinking habits and twins' similarity in alcohol use from adolescence to early adulthood (III)
5. to assess if genetic and shared environmental factors contribute differently among co-twin dependent and co-twin independent twins in alcohol-related behaviors in adolescence and in early adulthood (III)

The methodological part of the study aims to

6. examine the factor structure of the Finnish 20-item version of the General Health Questionnaire (GHQ-20) and compare the psychometric properties of the GHQ-20 and GHQ-12 in normative Finnish data of young adults (IV) in order to be able to use the GHQ-20 in the Study II.

4 Material and methods

4.1 The FinnTwin16 study

FinnTwin16 is a population-based, longitudinal study of five consecutive birth cohorts of Finnish twins born in the years 1975-1979. The birth cohorts (twins and their families) were identified from the Central Population Registry of Finland (Kaprio *et al.* 2002, Rose *et al.* 2001). The FinnTwin16 study was initiated in 1991 and it was initially compiled to study genetic and environmental determinants in consistency and change of health-related behaviors from late adolescence into early adulthood (Kaprio *et al.* 2002). The FinnTwin16 study has been approved by the Ethical Committee of the Faculty of Medicine, University of Helsinki and the Ethical Committee of the University of Indiana.

4.1.1 Questionnaires

Baseline assessments were collected through mailed questionnaires administered sequentially during the years 1991-1995, within two months of the twins' sixteenth birthdays. A total of 3065 twin families (n=6130 twin individuals) were contacted at the baseline. The five-year cohort sample yielded replies from 5563 twin individuals. The response rate for boys was 87% (n= 2682) and girls 93% (n= 2881). All respondent twins were surveyed again at the ages of 17 and 18½ and in early adulthood when they were 22-27 years old. Additional family questionnaire and parental questionnaires were sent concurrently to the twins' baseline questionnaire.

The baseline questionnaire for twins included a survey of health habits and attitudes, a symptom checklist, MMPI personality scales, leisure time activities and schooling as well as questions about the relationship between the respondent and his/her parents and co-twin, and questions of twins' similarity for zygosity determination. The subsequent three follow-up questionnaires at ages 17, 18½ and 22-27 years included measures on health habits (including questions on alcohol use and smoking), health-related attitudes, and questions of twins' social relationships. In early adulthood, at age 22-27, twins also filled

in a symptom checklist and the 20-item version of the General Health Questionnaire GHQ-20.

Family questionnaire, which was usually completed by the twins' mother, included questions on family medical history, the twins' pregnancy and delivery, twins' development, the co-twin relationship and questions about twins' similarity. A parental questionnaire was sent to each available parent, with most content similar if not identical to twins' questionnaire. A flowchart of the data collection of the FinnTwin16 study is presented in Figure 1.

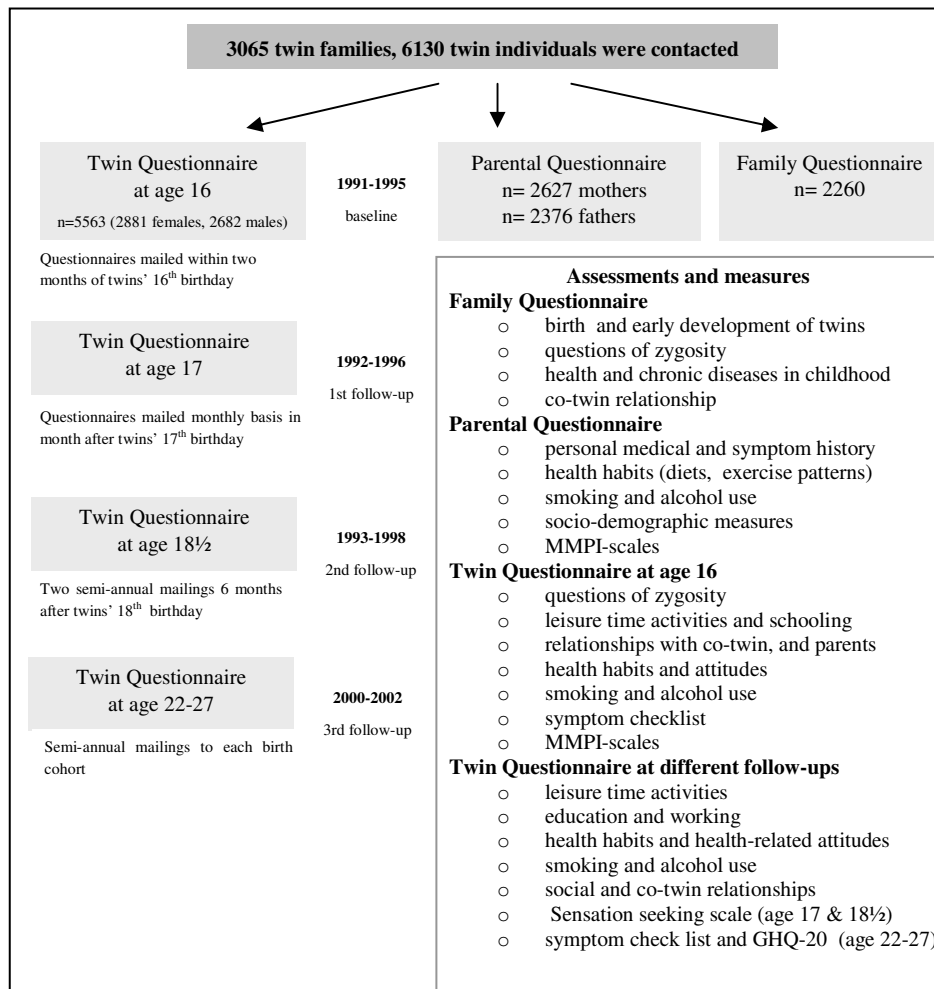


Fig. 1. Flowchart of the data collection and number of participants in the FinnTwin16 study

The number of twins included in different studies (I-IV) is presented in Table 1. Twins with missing data on zygosity were excluded from Studies I-III.

Table 1. Study populations of the present study

Study	Inclusion criteria	Number of twins included	Measures
I	Respondent twins at age 16 Known zygosity and co-twin dependence status	n= 5268 twin individuals	social interactions and leisure-time variables educational attainment parental education and SES
II	Subjects responded at both time points age 16 and ages 22-27 Known zygosity and co-twin dependence status	n=4478 twin individuals	MMPI (selected scales) GHQ-20 symptom checklist
III	Known zygosity and co-twin dependence status Complete pairs of same-sex twins No missing data on alcohol use variables	n= 3362 twin individuals, age 16 n=2912 twin individuals, age 22-27	abstinence drinking frequency intoxication frequency urban/rural status religiosity
IV	No missing data on the GHQ-20	n=4580 twin individuals, age 22-27	GHQ-12 GHQ-20

4.1.2 Zygosity determination

Zygosity was determined from validated questionnaire items regarding twins' similarity, including questions requesting information on genetically influenced characteristics such as eye color, hair color, facial appearance and texture, as well as questions on how often parents, peers, teachers and acquaintances confused the twins. Zygosity items were completed by the twins and by their parents. Previous studies have shown that using this method to determine zygosity has yielded accuracy rates of more than 95%, compared to these obtained by blood typing analysis (Rietveld *et al.* 2000; Sarna *et al.* 1978). Twins were classified as monozygotic males and females (MZM; MZF), same-sex dizygotic males and females (SSDZM; SSDZF) and opposite-sex dizygotic males and females (OSDZM; OSDZF). Twin pairs were classified as MZ, SSDZ and OSDZ. Studies I-III include only twins with known zygosity (N=5268).

4.2 Measures

4.2.1 Co-twin dependence

Co-twin dependence. Co-twin dependence was measured at the baseline (age 16) on the basis of responses to two questions in the twin questionnaire: “*In your own opinion are you dependent on your co-twin?*” and “*In your opinion is your co-twin dependent on you?*” with response alternatives yes and no. Most (99.1%) twins were able to give an unambiguous response to this simple question. Only “yes” and “no” answers were accepted, and twins with an unclear response were omitted. A total of 49 twins answered the first question ambiguously and 48 the second question.

Pair-wise dependence. Two measures of pair-wise dependence were included. The first, “*pair-wise dependence,*” was formed on the basis of the responses of each individual co-twin to the question “*In your own opinion are you dependent on your co-twin?*” Twin pairs were classified into three categories: *concordantly dependent* (both twins of a pair had reported themselves dependent), *concordantly independent* (both twins of a pair had denied being dependent) and *discordantly dependent* (one twin of a twin pair reported dependence and the co-twin reported independence).

Individual-based pair-wise dependence. The second measure of pair-wise dependence reflected each individual twin’s subjective perception of dependence within the twin pair. The measure was subsequently labeled as “*individual-based perception of pair-wise dependence*” in order to distinguish it from the first measure of “*pair-wise dependence.*” Twins were assigned to four groups based on each individual twin’s report of his/her own dependence and of each twin’s perception of his/her co-twin’s dependence. The classification was based on the responses to two questions: “*In your own opinion are you dependent on your co-twin?*” and “*In your opinion is your co-twin dependent on you?*” The *consonantly dependent* group included twins who considered themselves dependent and perceived also their co-twin as dependent on them. In the *consonantly independent* group, one twin individual reported not being dependent and perceived his/her co-twin as also non-dependent. The *dissonantly dependent* group consisted of twins who reported dependence for their own part, but viewed their co-twin as independent. The fourth group, in which twin individuals had reported themselves independent but viewed their co-twin as dependent, was labeled *dissonantly independent*.

Parental reports of co-twin dependence. In the family questionnaire, respondents (usually the mother) evaluated twins’ dependence at primary school age, when twins were 7-12 years of age. Both twins were rated separately with five response alternatives: *very dependent, dependent, sometimes dependent, and not at all dependent and don't know.* The first two alternatives were classified as co-twin dependent, the third and fourth were classified as not dependent, and “don’t know” responses were excluded. This form of classification gave a moderate and probably more accurate view of the extent of co-twin dependence compared to the other possible classifications explored. When the other classification alternatives were analyzed, the proportions of co-twin dependence varied, but the differences between genders and zygosity groups remained similar throughout.

4.2.2 Social contacts, leisure time and co-twin relationship

At the baseline, twins were asked a set of questions about their relationship to their co-twins and leisure-time companions. A total of seven social interaction and leisure-time measures were used. Respondents were asked to give information about whom they spent most of their leisure time with, the proportion of leisure time they spent with their co-twin or others, their best friend, and about hobbies and friends they had in common with their co-twin. The twins also reported whether they had been voluntarily separated from their co-twin for at least 24 hours and whether they missed their co-twin during the separation. Only a few respondents gave multiple answers, and it was possible to code some combinations into a single response; if this was not possible they were coded as a combination of answers into a multiple response category.

In early adulthood, twins were asked to give information about the frequency of their contact with their co-twin and their contentment with their co-twin relationship. Contact frequency was classified into three categories: *daily or almost daily*, *once a week*, and *once a month or less often*. For contentment with the co-twin relationship twins were assigned into groups of *very satisfied*, *mainly satisfied* and *not very satisfied* with the co-twin relationship. Twins also reported whether they were still residing with their co-twin and if not, at what age they had moved apart.

4.2.3 Academic achievement and school attendance

School attendance was determined at the baseline and at ages 17 and 18½ with three questions, i.e., whether the subjects were working, attending school or doing something else. At the baseline, most of the 16-year-olds were still in their final year of compulsory education in comprehensive school. Consequently, it was decided to analyze school attendance at the age of 17. Separate questions were asked in order to obtain information about the type of school they were attending as well as what they were doing at the moment if they were not at school. School types were classified at the age of 17 into three categories: *high school*, *vocational education* and *other*, which also included those not attending school. If information on schooling at age 17 was missing, it was supplied, when possible, on the basis of the data collected at the ages of 16 and 18½. Twins reported their level of academic achievement on a 5-point scale, from *much better than average* to *considerably worse than average*, by comparing their most recent term grades to the average of their class.

4.2.4 Alcohol use

In both adolescence and early adulthood, twins reported individually on their alcohol use. Alcohol use was measured with a set of structured self-report questionnaire items derived from the Finnish Adolescent Health and Lifestyle Survey (Rimpelä *et al.* 1988) that are widely used in Finnish epidemiological research. Three alcohol-use measures were

included in the analyses at the two time-points: initiation of alcohol use, drinking frequency and intoxication frequency. Frequency of alcohol use was assessed with the question: “*How often do you drink alcohol?*” with nine ordered response choices ranging from *daily* to *I don’t drink alcohol*. Alcohol use was classified into four categories according to the response alternatives: weekly (including *daily use to 1 to 2 times per week*), monthly (*1 to 2 times per month*), more rarely (*1 to 6 times per year or less*) and abstinent (*I don’t drink alcohol*). Intoxication frequency was assessed with the question: “*How often do you get really drunk?*” with four response alternatives, ranging from *once a week or more* to *never*. Analyses of drinking and intoxication frequency included only those pairs in which both twins had reported their initiation of alcohol use.

4.2.5 Symptom reports

Somatic symptoms. In adolescence psychosomatic symptoms were measured with a symptom checklist frequently used in Finnish survey studies of juvenile and adult health habits (Aro 1981, Huurre *et al.* 2003, Rimpelä *et al.* 1982). The scale was modified to include ten items: abdominal pain, tension or nervousness, irritability or tantrum, sleeping difficulties, headache, dizziness, loss of energy, pain in the back or neck, trembling hands and blushing. The items were rated on a four-point scale in terms of frequency (e.g., 1 *seldom or never*, 2 *once a month*, 3 *once a week*, 4 *almost daily*). The score of somatic symptoms was calculated as the over-all sum of the items, giving a range of 10 to 40, with the higher score indicating more problems. In early adulthood (age 22-27), psychosomatic symptoms included six items: abdominal pain, tension or nervousness, sleeping difficulties, headache, lower back pain and neck or shoulder pain. These items were scored similarly, giving a total range from 6 to 24.

Measures of psycho-emotional distress. The baseline questionnaire included selected scales from the MMPI, namely those relevant to the risk of alcoholism, such as Psychopathic Deviate and McAndrew’s Alcoholism scale (e.g. Graham 1997, Peele 1990). Psychological distress in adolescence was assessed with three Harris-Lingoes content scales: Social Imperturbability (Pd₃), Social Alienation (Pd_{4a}), and Self-Alienation (Pd_{4b}), which have been reported to be associated with psycho-emotional well-being (e.g., Almagor & Koren 2001, Kopper *et al.* 1998, Lilienfeld 1999). In addition Pd total score was included. Scales were scored with the original MMPI bimodal scoring system, using a true/false response format.

Harris-Lingoes content scales consist of groups of items empirically related to a specific content area, and they are labeled on the basis of Harris and Lingoes’s clinical judgment of the content (Graham 1987). A high score on Social Imperturbability has been found to correlate with social adeptness or, conversely, with anxiety in social situations (Graham 1987, Lilienfeld 1999). For this scale, the scoring was reversed so that in all included scales, a high(er) score indicated “more problems” and a lower score “fewer problems.” Thus a high score on Pd₃ reflects a person who is socially anxious and retiring, while a low score reflects a person who is socially comfortable and confident. Social Alienation measures comfort and adjustment with respect to one’s environment and daily life, and Self-Alienation measures the degree of “personal comfort” (Graham

1987). Both are reported to have positive and significant correlations with different dimensions of depression and psychological distress: Social Alienation with anxiety and Self-Alienation with depressiveness (e.g., Almagor & Koren 2001).

In early adulthood (age 22-27), psycho-emotional well-being was measured with the 20-item version of the General Health Questionnaire (GHQ) (Goldberg 1978, Goldberg & Williams 1988). Total score and four sub-scale scores of the GHQ-20 were analyzed separately. The subscales were derived from a factor analysis (Study IV) that yielded four factors, namely Depressiveness, Social Functioning, Self-Confidence, and Anhedonia. The GHQ was scored by using a 4-point Likert scale (0-1-2-3), providing a sum score of general symptom level for each subscale and total score of the GHQ. Each item had four response choices: 0 *Not at all*, 1 *Same as usual*, 2 *Rather more than usual* and 3 *Much more than usual*, so that a high(er) score on any question showed greater distress, giving a range of 0–36.

4.2.6 Socio-demographic and family background variables

Parents' socio-economic status (SES) and parents' educational level were analyzed separately for each responding parent. Socio-economic status was based on responses to the question “*What is your occupation or, if you are not at work, your former occupation?*” The coding into socio-economic groups was done according to the Finnish Central Statistical Office's 1987 classification, using present employment status. SES was grouped into five categories: *self-employed*, *employee* (upper- and lower-level employees), *worker*, *farmer* (farmer employers, self-employed farmers) and *other* (students, pensioners, unknown socio-economic status).

Information on parents' educational background was elicited with two questions “*What is your basic education?*” and “*How long was your vocational education if you have had one after basic education?*” Educational level was classified into basic education (comprehensive school level studies or less), lower secondary education (basic education and a maximum of 2 years of studies in vocational education or in high school), upper secondary education (high school completed or more than 2 years of studies in vocational education) and tertiary education (university or other higher education degree).

Urban/rural status was based on the classification of the community of residence of the family of the twins at age 16, and categorized as either urban or rural as defined by Rose *et al.* (1999). Finland was divided into two areas based on the Nomenclature des Unités Territoriales Statistiques, a regional classification system of the European Union. The “urban” area consisted of Uusimaa, the area surrounding Helsinki, together with other southern regions with a population density of 45 inhabitants/km². The rural area consisted of the rest of Finland with population density of seven inhabitants/km² (Winter *et al.* 1999).

Religiosity was assessed with the Wiggins (1966) Religious Fundamentalism (REL) scale of the Minnesota Multiphasic Personality Inventory (MMPI) administered to both twins and parents at the baseline as described in detail elsewhere (Winter *et al.* 1999, Winter *et al.* 2002).

4.3 Study design

Different sample constructions have been used according to the purposes of each original study. Cross-sectional and longitudinal study designs were used in the four studies as follows:

- Study I: Twins were studied cross-sectionally by mailed questionnaires at age 16 years.
- Studies II and III: The cross-sectional data were derived from mailed questionnaires at age of 16 years and followed up at age 22-27 years.
- Study IV: Cross-sectional data for the factor analytic study of the GHQ-20 were derived from mailed questionnaires at age 22-27 years.

4.4 Statistical analysis

The data were analyzed using basic methods for longitudinal epidemiological studies. The data were analyzed with complex survey data analysis methods in Stata (Stata Statistical Software, release 8.0, Stata Corporation) to take the possible intrapair correlations of the twin data into account.

4.4.1 Descriptive statistics and regression analyses

Descriptive statistics illustrate the prevalence of different variables by co-twin dependence, twin-type and gender. Prevalence refers to cases in different categories (variables) that exist at a specified time. The differences in percentages between co-twin dependent and co-twin independent twins and between different twin types and gender were tested with Wald F-statistics, a design-based chi-square test adjusted for correlated data (Rao & Scott 1984).

Logistic regression modeling with odds ratios (OR) and 95% confidence intervals (CI) were used to assess whether there was an association between co-twin dependence and a given parameter (e.g., social interactions, academic achievement and educational attainment, parental SES, residing together). The modeling process was usually done in two phases. Each variable was examined individually to see how strongly it was related to co-twin dependence. In Study I, all variables showing a significant single covariate association with co-twin dependence were included in the multivariate model. Due to the existence of gender and zygosity effects, all regression models were adjusted for these factors.

In the Study II, the associations and differences in means between co-twin dependence and reports of somatic and psychological symptoms were analyzed using multiple linear regressions. All regression analyses and p-values were adjusted for the presence of gender and zygosity effects in co-twin dependence.

The associations between educational attainment and parental SES were additionally analyzed with trend analysis using binary logistic regression, where variables were treated as continuous score variables instead of as categorical variables. The category of missing data was excluded from the trend analysis.

4.4.2 Structural equation modeling

In Study III, quantitative genetic analyses were based on Structural Equation Modeling (SEM) conducted with the statistical package Mx (Neale *et al.* 1999). SEM is based on the twin study methodology, which uses the difference in the proportion of shared genes between MZ and DZ twins to estimate the relative contributions of genetic and environmental factors to observed traits. Variance decomposition follows the logic of the basic twin model, where genetic influences are assumed to correlate 1.0 for MZ twins and 0.5 for same-sex DZ twins, and environmental variances of MZ and DZ twins are assumed to be equivalent (i.e., both twin types have similar environments with respect to the phenotype being studied). The relative contribution of genetic and environmental influences to trait variation can be resolved using variance component models that specify genetic and environmental sources of phenotypic covariance in MZ and DZ twin pairs. In this way it can be determined which parameter estimates provide the smallest discrepancies with the data and thereby provide the best fit between the model and the data.

Variance of a phenotype or each trait can be partitioned into additive genetic influences (A), or non-additive, i.e. dominant (D) genetic influences, common environmental influences (C), i.e. environmental effects shared by siblings in a family, and unique environmental influences (E), i.e. effects which are not shared. The definitions of common and unique environmental effects are based on the way they influence MZ and DZ twin similarity. The common environmental variance is caused by experiences or conditions that are shared by twins, thus increasing both MZ and DZ correlations. Unique environmental variance is non-shared, influencing only one co-twin, thereby creating differences between co-twins and decreasing twin correlations. Common environmental effects (C) and non-additive genetic effects (D) cannot be modeled simultaneously in twins who are reared together. Thus, classical twin studies estimate variance components using ACE or ADE models and their submodels (AE, CE, DE, E).

Polychoric correlations for SEM were computed from contingency tables using the statistical package Mx (Neale *et al.* 1999). When polychoric correlations are used it is assumed that there is an underlying normal distribution for the scores on the observed categorical variable. The correlations for monozygotic (MZ) and dizygotic (DZ) twins usually allow the first estimation of the genetic and the environmental causes of familial resemblance (Plomin *et al.* 1997).

As there were significant gender differences in the prevalence of co-twin dependence and of most outcome variables of alcohol use, gender was added to the models to differentiated sex effects from the estimates of variance. Hence, univariate model-fitting analyses were conducted for concordantly dependent and concordantly independent twins for the four twin types (male and female MZ twins and male and female same-sex DZ twins) to decompose the variance of alcohol use measures.

The modeling was conducted in phases. First a full model was fitted, allowing different additive genetic (A_d), common environmental (C_d) and unique environmental (E_d) influences for co-twin dependent twins and A_i , C_i and E_i influences for independent twins, as well as different ACE effects for males and females to account for the observed variance on alcohol use measures. The analyses were conducted separately for the two time points, viz. adolescence (age16) and early adulthood (ages 22-27). Modeling began with a model, which enabled to assess the magnitude of genetic and environmental effects separately on co-twin dependent and independent twins, but allowed the magnitude of paths a^2 , c^2 and e^2 to differ across gender. The modeling proceeded by testing whether the paths could be set equal for co-twin dependent and independent twins. A more restricted model constraining ACE_d and ACE_i effects to be equal for dependent and independent twins was compared to the full model using likelihood ratio χ^2 . Thresholds were allowed to differ for dependent and independent twins as well as for males and females in both models. After fitting the full model the most parsimonious model, i.e. the model with the fewest parameters, was sought by fitting a series of sub-models and testing the significance of each factor by removing the corresponding path from the model. For example, a model in which the genetic influences (path a_d^2 and a_i^2) were fixed at 0 was compared with a model containing all three sources of variation (paths a_d^2 , c_d^2 and e_d^2 for dependent and paths a_i^2 , c_i^2 and e_i^2 for independent twins).

The significance of the change in model fit, when the full models were constrained to be equal for dependent and independent twins or parameters were omitted (i.e. removing the corresponding path) from the sub-models or the sub-models were constrained to be equal, was tested with estimating the change in χ^2 between the different models. A likelihood ratio χ^2 with p-value above .05 indicates a good fit to the data, and a significant change in χ^2 ($p < .05$) indicates that the model with fewer degrees of freedom should be adopted. Akaike's (1987) Information Criterion (AIC), calculated from the model's chi-square minus its degrees of freedom, offers another measure of model-fit and is conventionally used to determine the best-fitting models. The model with the lowest (negative) AIC value is generally considered the best. Root Mean Squared Error of Approximation (RMSEA) with a value below 0.1 also indicates a good fit of the model (Neale *et al.* 1999). Similar model-fitting analyses were conducted for the follow-up data, i.e. twins in early adulthood.

4.4.3 Factor analyses

As previous studies of the psychometric properties or the factor structure of Goldberg's (1972) original and complete GHQ-20 version were lacking, factor analyses were carried out here. Exploratory factor analyses (EFA) and confirmatory factor analyses (CFA) were conducted to obtain the factor structure for the GHQ-20. The use of two different datasets of twins made it possible to replicate the results directly and to test the models in a matched subsample. Additional invariance testing was performed to test the equivalency of the models between the two datasets using AMOS 5.0 software (Arbuckle 1997, Byrne 2001). The factor analyses are described in more detail in Study IV.

5 Results

5.1 Prevalence of co-twin dependence (I, II)

In adolescence, at age 16, 25.6% of twins reported being dependent on their co-twin (Table 2). Co-twin dependence was more common in MZ (33.6%) twins than in SSDZ (19.9%) and OSDZ (18.7%) twins, and girls were more likely to report dependence than boys in all zygosity groups (all $p < .05$).

Regarding *pair-wise dependence*, most of the twins could be classified as concordantly independent (66.5%). MZ twins were more likely than DZ twins to be from concordantly dependent twin pairs. In discordantly dependent pairs, there were no significant differences in prevalence between zygosity groups. With respect to the *individual-based perception of pair-wise dependence*, most of the respondents perceived their co-twin relationship as consonantly independent (71.7%). MZ (30.8%) twins were more likely to perceive their co-twin relationship as consonantly dependent than SSDZ (15.1 %) twins or OSDZ (14.2) twins. Gender differences were found in both measures of pair-wise dependence, females being more likely to be from concordantly and consonantly dependent groups than males.

According to the family questionnaire, which was usually filled by the mothers, twins were more likely to be regarded as dependent on each other compared to the twins' own reports. However, when different twin types were considered, mothers' perceptions of twins' dependence were similar to the twin's own reports. Significant gender differences in dependence were reported only among OSDZ twins, with boys being more likely to be reported dependent than girls.

Table 2. Prevalence of co-twin dependence and pair-wise dependence by zygosity and gender reported by twins at age 16

	All		MALES						FEMALES					
			MZ		SSDZ		OSDZ		MZ		SSDZ		OSDZ	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
“I am dependent ” (n=5178)	1327	(25.6)	192	(28.1)	123	(14.1)	153	(17.0)	368	(37.5)	218	(25.9)	183	(20.3)
“My co-twin is dependent” (n=5164)	1259	(24.4)	210	(30.7)	137	(15.7)	154	(17.3)	363	(37.1)	217	(25.9)	178	(19.8)
Pair-wise dependence (n=5100)														
Concordantly dependent	724	(14.2)	124	(18.7)	46	(5.4)	74	(8.3)	284	(29.2)	122	(14.6)	74	(8.3)
Concordantly independent	3392	(66.5)	414	(62.4)	662	(77.5)	634	(71.5)	524	(53.8)	524	(62.8)	634	(71.5)
Discordantly dependent	984	(19.3)	126	(19.0)	146	(17.1)	178	(20.2)	166	(17.0)	188	(22.5)	179	(20.2)
Individual-based pair-wise dependence (n=5141)														
Consonantly dependent	1019	(19.8)	180	(26.6)	98	(11.3)	122	(13.7)	329	(33.7)	158	(18.9)	132	(14.8)
Consonantly independent	3684	(71.7)	459	(67.7)	709	(81.9)	709	(79.6)	578	(57.8)	561	(56.1)	668	(74.7)
Dissonantly dependent	203	(4.0)	10	(1.5)	22	(2.5)	29	(3.3)	36	(3.7)	57	(6.8)	49	(5.5)
Dissonantly independent	235	(4.6)	29	(4.3)	37	(4.3)	31	(3.5)	34	(3.5)	59	(7.1)	45	(5.0)

Note: “n” refers to the number of individuals in each group. MZ monozygotic; SSDZ same-sex dizygotic; OSDZ opposite-sex dizygotic twins.

5.2 Co-twin dependence and twins' social interactions and leisure time (I, II)

In adolescence co-twin dependence was strongly associated with twins' social interactions (Figure 2) and leisure time activities. Co-twin dependent twins were more likely to be each other's best friends (OR 5.50, CI 4.41-6.86) and to spend their leisure time with each other than co-twin independent twins. Dependent twins were also more likely to have friends (OR 5.10, OR 3.75-6.92) and hobbies in common (OR 3.34 CI 2.60-4.30) than independent twins. Additionally, co-twin dependent twins were more likely to report that they had not been separated or been apart from their co-twin (OR 3.12, CI 2.18-4.47). Longing often for the co-twin when separated had the strongest association with co-twin dependence. Dependent twins were more likely to miss their co-twin during the separation than independent twins (OR 22.6, CI 13.3-38.6). If the twins spent most of their leisure time alone, they were more likely to be independent. More detailed results are presented in Study I.

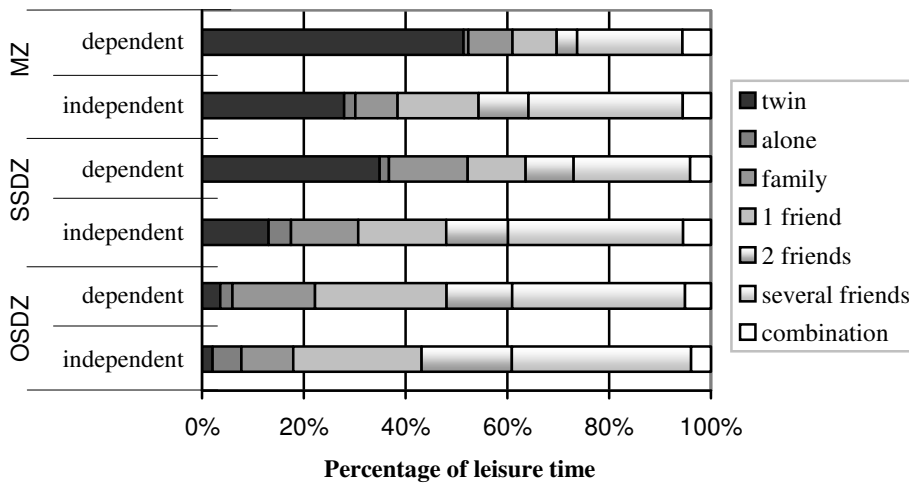


Fig. 2. Leisure-time companionship by zygosity and dependence in adolescence

A similar association between co-twin dependence and co-twin interaction was found also in early adulthood (Figure 3, Table 3). Twins who had reported co-twin dependence in adolescence relative to co-twin independent twins were more likely to remain in daily contact in early adulthood (OR 1.79, 95% CI 1.36-2.36). Dependent twins were more likely to be very satisfied with their co-twin relationship than independent twins (OR 1.47, CI 1.12-1.92) and they were more likely to move apart at an older age than independent twins (difference in means 0.17 years, CI 0.01-0.35). Analyses by zygosity revealed that MZ twins were more likely to be in daily contact than DZ twins, both in the dependent and the independent groups (Figure 3), and MZ twins were more likely to be very satisfied with their co-twin relationship than DZ twins in both the dependent and independent groups.

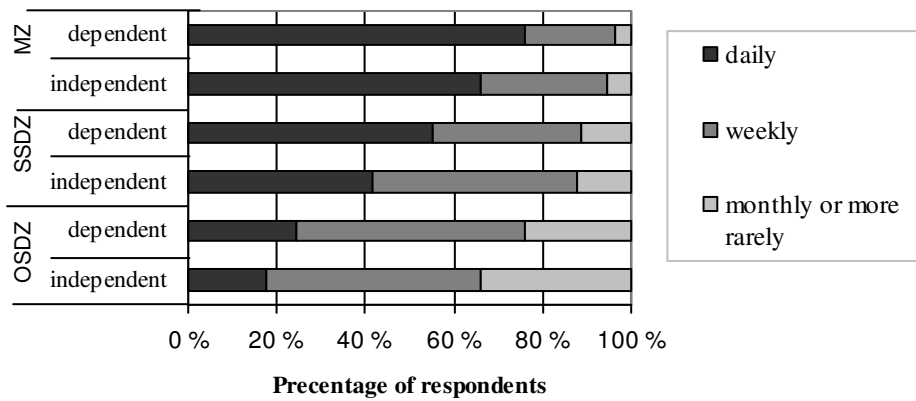


Fig. 3. Contact frequency and co-twin dependence in early adulthood

Table 3. Selected characteristics of co-twin contact and contentment with the co-twin relationship in relation to co-twin dependence in early adulthood (Study II)

	Dependent		Independent		OR	CI
	n	(%)	n	(%)		
Residing together	190	(10.2)	248	(7.3)	1.28	0.95-1.72
Contact frequency*						
Once a month or less	116	(12.1)	593	(18.8)	1	
Weekly	323	(33.6)	1335	(42.2)	1.19	(0.92-1.55)
Daily	523	(54.4)	1221	(38.7)	1.79	(1.36-2.36)
Satisfaction with co-twin relationship						
Not very satisfied	87	(8.2)	392	(11.6)	1	
Satisfied	398	(37.3)	1472	(43.4)	1.14	0.87-1.49
Very satisfied	583	(54.6)	1530	(45.1)	1.47	1.12-1.92

Regression analyses are adjusted for gender and zygosity. * Twins residing together are excluded.

5.3 Co-twin dependence and educational attainment (I)

When twins' school attendance at age 17 was analyzed in relation to co-twin dependence, it was found that twins who had not chosen the most common educational careers (i.e. high school or vocational education) after compulsory education were more likely to be co-twin dependent (OR 1.35, CI 1.06-1.72). A significant trend ($p=.01$) between school type and co-twin dependence was also found, and co-twin dependent twins were more likely to attend vocational education or to belong to the "other" category (i.e. other school/course, working, military service, unemployed or being just at home) than twins who had chosen high school. When the effect of gender was analyzed separately, this tendency was stronger among boys ($p=.001$), but no longer significant among girls. However, there were no differences in academic achievement between dependent and independent twins on the basis of term grades.

5.4 Co-twin dependence, psychosomatic symptoms and mental well-being (II, IV)

In adolescence, co-twin dependent twins reported more somatic complaints and psychological distress than co-twin independent twins (Table 4). Dependent twins also scored higher on Pd than independent twins ($F_{1,2453}=2.39$, $p=.036$). In adulthood, twins who had reported dependence in adolescence had a greater tendency to suffer from psychosomatic symptoms ($F_{1,2441}=11.25$, $p=.001$), Depressiveness ($F_{1,2452}=6.85$, $p=.009$), and lack of Self-Confidence ($F_{1,2448}=4.04$, $p=.04$), than independent twins, however after adjustment these differences became non-significant.

Table 4. Means and 95% confidence intervals (CI) for somatic and psycho-emotional symptoms in co-twin dependent and independent twin individuals in adolescence and in early adulthood (n=4478) (Study II)

Symptom scales	Dependent twins		Independent twins		*p-value
	Mean	(CI)	Mean	(CI)	
Adolescence					
Somatic symptoms	17.51	(17.18-17.83)	16.28	(16.12-16.45)	<.001
Harris-Lingoes scales					
Social imperturbability	2.60	(2.49-2.71)	2.29	(2.23-2.35)	<.001
Social Alienation	4.49	(4.33-4.65)	4.09	(4.00-4.17)	<.001
Self-Alienation	2.94	(2.79-3.09)	2.62	(2.54-2.70)	<.001
PD-scale	16.75	(16.37-17.12)	16.42	(16.22-16.62)	.036
Early adulthood					
Somatic symptoms	10.89	(10.68-11.11)	10.48	(10.36-10.59)	.08
GHQ-20					
Social Functioning	7.21	(7.03-7.38)	7.28	(7.18-7.35)	.330
Depressiveness	6.61	(6.29-6.94)	6.13	(5.95-6.30)	.06
Lack of Self-Confidence	1.18	(1.08-1.27)	1.07	(1.02-1.12)	.106
Anhedonia	3.11	(3.03-3.20)	3.13	(3.08-3.17)	.833
GHQ-20	18.10	(17.53-18.68)	17.58	(17.28-17.89)	.314

* p-values are adjusted for zygosity and gender

When twins were analyzed by zygosity groups, dependent MZ twins scored significantly lower on Social Alienation (Pd_{4a}) in adolescence than SSDZ twins (Table 5). On Self-Alienation (Pd_{4b}) and Pd total score, dependent MZ twins scored lower than dependent SSDZ and dependent OSDZ twins. Among independent twins, MZ twins scored lower on Social Alienation (Pd_{4a}), Self-Alienation (Pd_{4b}) and Pd total score than independent SSDZ and independent OSDZ twins. Significant differences were not found between SSDZ and OSDZ twins.

In early adulthood (Table 6), dependent SSDZ twins reported more problems in Social Functioning than dependent MZ twins. In the independent group, MZ twins scored lower on Depressiveness, problems with Self-Confidence, and the GHQ-20 than independent SSDZ twins and independent OSDZ twins. MZ twins also scored lower on Anhedonia than OSDZ twins.

Table 5. Means and 95% confidence intervals (CI) for somatic and psycho-emotional symptoms in co-twin dependent and independent twins by zygosity in adolescence (n=4478) (Study II)

	Dependent twins				Independent twins			
	MZ	SSDZ	OSDZ	Test for difference ¹	MZ	SSDZ	OSDZ	Test for difference ¹
Symptom scales	mean (CI)	mean (CI)	mean (CI)	p-value, post hoc ²	mean (CI)	mean (CI)	mean (CI)	p-value, post hoc ²
Somatic symptoms	17.50 ^e (16.98-18.01)	17.70 ^d (17.10-18.30)	17.33 ^e (16.73-17.94)	.735	16.30 (15.97-16.64)	16.25 (16.00-16.53)	16.30 (16.04-16.56)	.792
Harris-Lingoes Scale:								
Social Imperturb.	2.57 ^e (2.39-2.75)	2.75 ^d (2.55-2.95)	2.51 ^f (2.32-2.70)	.187	2.27 (2.14-2.39)	2.31 (2.20-2.41)	2.30 (2.21-2.40)	.894
Social Alienation	4.32 ^e (4.08-4.57)	4.70 ^e (4.41-4.99)	4.56 ^f (4.25-4.86)	.095	3.89 (3.71-4.07)	4.16 (4.01-4.31)	4.17 (4.04-4.30)	.011, MZ<SSDZ ^b , OSDZ ^b
Self-Alienation	2.60 (2.39-2.82)	3.18 ^e (2.89-3.47)	3.26 ^e (2.98-3.53)	<.001, MZ<SSDZ ^a , OSDZ ^a	2.38 (2.23-2.53)	2.66 (2.53-2.79)	2.77 (2.65-2.90)	<.001, MZ<SSDZ ^b , OSDZ ^a
PD-scale	16.03 (15.45-16.61)	17.26 (16.58-17.94)	17.39 (16.70-18.07)	p=.0018, MZ<SSDZ ^b , OSDZ ^b	15.83 (15.45-16.23)	16.60 (16.27-17.93)	16.69 (16.37-17.01)	.0017, MZ<SSDZ ^b , OSDZ ^a

Note: MZ, monozygotic twins; SSDZ, same-sex dizygotic twins; OSDZ, opposite-sex dizygotic twins.

¹ Difference between zygosity groups, Wald F-statistic p-value, adjusted for gender.

² Difference between zygosity groups after post hoc-analysis; only significant differences are reported: ^a p≤0.001; ^b p≤0.01; ^c p≤0.05, adjusted for gender.

The mean of co-twin dependent twins differs from the mean of co-twin independent twins within zygosity group: ^d p≤0.001, ^e p≤0.01, ^f p<0.05, adjusted for gender.

Table 6. Means and 95% confidence intervals (CI) for somatic and psycho-emotional symptoms in co-twin dependent and independent twins by zygosity in early adulthood (n=4478) (Study II)

Symptom scales	Dependent twins				Independent twins			
	MZ mean (CI)	SSDZ mean (CI)	OSDZ mean (CI)	Test for difference ¹ p-value, post hoc ²	MZ mean (CI)	SSDZ mean (CI)	OSDZ mean (CI)	Test for difference ¹ p-value, post hoc ²
Somatic symptoms	10.89 (10.55-11.22)	11.02 (10.63-11.42)	10.78 (10.36-11.19)	.706	10.45 (10.22-10.67)	10.44 (10.24-10.64)	10.53 (10.34-10.71)	.312
GHQ-20 ²								
Social functioning	7.00 (6.73-7.27)	7.60 (7.28-7.92)	7.14 (6.85-7.44)	.012, MZ<SSDZ ^b	7.19 (7.02-7.35)	7.22 (7.07-7.38)	7.37 (7.23-7.51)	.138
Depressiveness	6.61 ^f (6.11-7.11)	6.97 (6.40-7.54)	6.27 (5.64-6.89)	.374	5.81 (5.47-6.15)	6.15 (5.84-6.45)	6.35 (6.06-6.63)	.011 MZ<SSDZ ^c , OSDZ ^b
Low Self-Confidence	1.14 (0.99-1.28)	1.33 (1.14-1.52)	1.10 (0.93-1.26)	.184	0.97 (0.87-1.07)	1.10 (1.01-1.19)	1.12 (1.03-1.20)	.014 MZ<SSDZ ^b , OSDZ ^b
Anhedonia	3.12 (2.98-3.25)	3.12 (2.96-3.29)	3.11 (2.95-3.37)	.973	3.05 (2.96-3.13)	3.13 (3.04-3.21)	3.18 (3.10-3.26)	.059 MZ<OSDZ ^c
GHQ-20 total	17.85 (16.95-18.74)	19.02 (17.96-20.09)	17.61 (16.56-18.66)	.154	17.00 (16.42-17.58)	17.59 (17.07-18.11)	18.01 (17.53-18.50)	.007 MZ<SSDZ ^c , OSDZ ^b

Note: MZ, monozygotic twins; SSDZ, same-sex dizygotic twins; OSDZ, opposite-sex dizygotic twins.

¹ Difference between zygosity groups, Wald F-statistic p-value, adjusted for gender.

² Difference between zygosity groups after post hoc-analysis; only significant differences are reported: ^a p≤0.001; ^b p≤0.01; ^c p≤0.05, adjusted for gender.

The mean of co-twin dependent twins differs from the mean of co-twin independent twins within zygosity group: ^d p≤0.001, ^e p≤0.01, ^f p<0.05, adjusted for gender.

Twin Group Differences in symptom reporting. Analyses of *pair-wise dependence* revealed that in adolescence, dependent twins from discordantly dependent pairs were not more likely to report psychological distress than dependent twins from concordantly dependent pairs. In early adulthood only one significant difference was found, dependent twins from concordantly dependent pairs scored higher in Anhedonia than dependent twins from discordantly dependent pairs ($p=.047$). When independent twins from concordant and discordant pairs were compared, adolescent twins from discordant pairs scored higher on somatic symptoms ($p=.016$) and on Self-Alienation ($p=.009$) than independent twins from concordantly independent pairs. In early adulthood no differences were found between independent twins from concordant or discordant pairs.

When *individual-based perception of pair-wise dependence* was analyzed in relation to somatic complaints and psychological distress, significant differences were found between the four groups both in adolescence and in early adulthood. In adolescence, twins from consonantly dependent and the two dissonantly dependent groups scored higher on somatic complaints and psychological distress than twins who perceived their co-twin relationship to be consonantly independent. In early adulthood, differences in somatic symptoms and psychological distress between twins with different *perceptions of pair-wise dependence* had in general diminished. However, dissonantly dependent twins had significantly higher rates of Depressiveness (difference in means 0.84, CI 0.02-0.165) than the reference group of consonantly independent twins and significantly more problems with Self-Confidence (difference in means 0.31, CI 0.06-0.56) than consonantly independent twins and consonantly dependent twins (post hoc, $p=.05$).

5.5 Co-twin dependence and alcohol-related behavior (III)

When twins were analyzed as individuals, dependent twins did not differ significantly from independent twins in their drinking patterns at the age of 16, with the exception of dependent MZ males, who were significantly more likely to be abstinent than independent MZ males ($F_{1,349}=4.78$, $p=.03$). While few differences in prevalence of abstinence were found between dependent and independent twins and no effect of co-twin dependence on drinking or intoxication frequency, significantly higher pair resemblances in co-twin dependent twins were found for drinking behavior compared to independent twins. The greater similarity in drinking behavior carried over from adolescence into early adulthood (Table 7).

Table 7. Polychoric correlations for drinking patterns by zygosity for co-twin dependent and independent same-sex male and female twin pairs in adolescence (n = 1342 pairs) and in early adulthood (n = 1078 pairs) (Study III)

	MALES						FEMALES					
	Dependent			Independent			Dependent			Independent		
	n	r	95% CI for r	n	r	95% CI for r	n	r	95% CI for r	n	r	95% CI for r
ADOLESCENCE												
Abstinence												
Monozygotic twins	(61)	.98	(.88-1.00)	(206)	.86	(.75-.93)	(142)	.98	(.94-1.00)	(261)	.95	(.89-.98)
Dizygotic twins	(23)	.91	(.50-.99)	(327)	.83	(.73-.90)	(61)	.95	(.74-.99)	(261)	.87	(.77-.94)
Drinking frequency ¹												
Monozygotic twins	(37)	.75	(.50-.99)	(140)	.74	(.60-.88)	(101)	.85	(.69-1.00)	(197)	.74	(.62-.86)
Dizygotic twins	(14)	.90	(.65-1.00)	(208)	.59	(.47-.71)	(47)	.80	(.57-1.00)	(196)	.56	(.41-.71)
Intoxication frequency ¹												
Monozygotic twins	(37)	.51	(.13-.76)	(140)	.74	(.63-.82)	(101)	.81	(.69-.89)	(197)	.73	(.61-.81)
Dizygotic twins	(14)	.96	(.70-1.00)	(210)	.54	(.41-.65)	(47)	.91	(.77-.97)	(196)	.60	(.47-.70)
EARLY ADULTHOOD												
Abstinence												
Monozygotic twins	(44)	.83	(.33-.98)	(161)	.77	(.42-.94)	(123)	.95	(.78-1.00)	(227)	.74	(.43-.91)
Dizygotic twins	(14)	.67	(-.29-.99)	(234)	.68	(.32-.89)	(48)	.75	(.26-.96)	(227)	.74	(.43-.91)
Drinking frequency ¹												
Monozygotic twins	(37)	.85	(.64-.95)	(148)	.64	(.46-.77)	(113)	.49	(.28-.65)	(209)	.43	(.27-.56)
Dizygotic twins	(11)	.18	(-.80-.82)	(216)	.21	(.03-.39)	(40)	.48	(.11-.73)	(209)	.32	(.16-.47)
Intoxication frequency ¹												
Monozygotic twins	(37)	.71	(.43-.87)	(148)	.59	(.45-.70)	(113)	.67	(.51-.78)	(209)	.59	(.48-.68)
Dizygotic twins	(11)	.33	(.42-.84)	(216)	.35	(.21-.47)	(40)	.57	(.24-.77)	(209)	.40	(.25-.52)

Note: ¹Correlations for all concordantly drinking female and male twin pairs.

r ,polychoric- correlations are computed with Mx.

The model-fitting results suggest that the genetic contribution to individual differences in drinking patterns, especially in adolescence, is dependent on the nature of the pair-wise relationship (Table 8). The drinking behavior of co-twin dependent twins in adolescence was due more to shared environmental influences, with insignificant genetic factors. Conversely, genetic influences on drinking habits were expressed among independent twins, and especially with drinking frequency ($a^2_i = 29\%$) and intoxication frequency ($a^2_i = 38\%$). The importance of non-shared environment in co-twin dependent twins was less important than in independent twins.

Table 8. Partitioning of variance into genetic and environmental influences on drinking habits under the best-fitting model in adolescence (Study III)

Model	Variance components for co-twin dependent twins			Variance components for co-twin independent twins		
	a^2_d	c^2_d	e^2_d	a^2_i	c^2_i	e^2_i
Abstinence ¹						
CE _d , ACE _i	-	.97 (.93-.99)	0.03 (.01-.07)	.14 (.00-.29)	.78 (.64-.89)	0.09 (.05-.14)
Drinking Frequency ¹						
CE _d , ACE _i	-	.81 (.72-.88)	.19 (.12-.28)	.29 (.07-.51)	.44 (.24-.62)	.27 (.20-.34)
Intoxication Frequency ²						
CE _d , ACE _i	-	.81 (.72-.87)	.19 (.13-.28)	.36 (.16-.57)	.38 (.19-.54)	.26 (.20-.33)

¹ Separate variance components and prevalences for co-twin dependent and independent twins.

² Separate variance components, but same prevalences for co-twin dependent and independent twins.

The magnitude of genetic effects on drinking frequency appeared to increase with age, whereas the influence of the common environment decreased. The modeling results suggested similar genetic and environmental influences for abstinence and drinking frequency for both co-twin dependent and independent twins in early adulthood, an AE model for both groups (Table 9). However, in intoxication frequency the variance components of co-twin dependent and independent twins differed, the best-fitting model having components CE_d for dependent twins and AE_i for independent twins.

Table 9. Partitioning of variance into genetic and environmental influences on drinking habits under the best fitting full model in early adulthood (Study III)

Model	Variance components for co-twin dependent twins			Variance components for co-twin independent twins		
	a^2_d	c^2_d	e^2_d	a^2_i	c^2_i	e^2_i
Abstinence ¹						
CE _d , CE _i	-	.78 (.67-.86)	.22 (.14-.32)	<i>equal</i>	<i>equal</i>	<i>equal</i>
Drinking Frequency ¹						
AE _d , AE _i	.53 (.45-.61)	-	.46 (.39-.55)	“	“	“
Intoxication Frequency ²						
CE _d , AE _i	-	.65 (.53-.74)	.35 (.26-.47)	.61 (.53-.68)	-	.39 (.32-.47)

¹ Different prevalences, but same variance components for co-twin dependent and independent twins.

² Different prevalences and variance components for co-twin dependent and independent twins.

“equal” signifies that variance components are equal for co-twin dependent and for independent twins.

5.6 Co-twin dependence and family background (I, III)

When parents' educational background and socio-economic status (SES) were examined in relation to co-twin dependence, single covariate analysis found that twins whose fathers were characterized by lower SES were more likely to be co-twin dependent. Among farmer fathers, this association was significant (OR 1.86, CI 1.26-2.74), and a non-significant tendency was also found among worker fathers. A significant trend was found between co-twin dependence and mother's education ($p=0.008$, trend analysis), but not with father's education. Mothers with a basic education were more likely to have dependent twins (OR 1.35, 95% CI 1.02-1.79). In the multivariate model, where all the parental background variables were included, the results were similar, with father's SES (OR 2.08, CI 1.32-3.27 for farmer fathers) and mother's education ($p=0.043$, trend analysis) showing significant associations with co-twin dependence.

The analyses of urban/rural status and familial religiosity produced no associations between these factors and co-twin dependence, neither when twins were analyzed as individuals nor when they were analyzed as concordant dyads of dependent and independent twins. Co-twin dependent twins and co-twin independent twins were equally likely to live in urban and rural areas, and they were equally likely to be from religious and non-religious families.

5.7 Factor analyses of the GHQ-12 and GHQ-20 (IV)

In this study confirmatory factor analysis (CFA) was used to explore competing models of the GHQ-12. The factor structure for the GHQ-20 was obtained with an exploratory factor analysis (EFA), and the factor models were tested with CFA. The use of two different datasets of twins made it possible to replicate the results directly and to test the models in a matched subsample (see Study IV).

In the two datasets, Twin1 and Twin2, exploratory factor analysis of the GHQ-12 provided a two-factor model consisting of depression and social dysfunction. This model is similar to the positive/negative model proposed by Andrich and van Schoubroeck (1989) (different models are presented in Study IV). In the confirmatory factor analysis of the GHQ-12, two models showed good levels of fit in five of the six indicators, with the Worsley and Gribbin (1977) three-factor model providing the best fit, followed by the three-factor model of Graetz (1991). The CFA in the Twin2 dataset provided similar results as the CFA in the Twin1 dataset. Due to multiple cross-loadings in Worsley and Gribbin's model the model of Graetz, which provided the next-best fit on the basis of goodness-of-fit measures, was considered the most preferable model, as it approached much more closely the criterion of simple structure and it was more parsimonious than the model of Worsley and Gribbin. The results of the CFA supported the idea that the 12-item GHQ is relatively consistent and could be interpreted in terms of the three-factors, namely anxiety/depression, social dysfunction and loss of self-confidence, suggested by Graetz (1991).

A similar factor structure with similar psychometric properties was also extracted from the longer 20-item version of the GHQ (GHQ-20), with an additional fourth factor of "anhedonia." The results of exploratory factor analysis of the GHQ-20 based on a scree plot indicated the presence of a four-factor solution, whereas the criterion of eigenvalue (>1) suggested a three-factor solution. Consequently, both solutions were retained for further analyses. Principal Axis Factoring (PAF) with oblique rotation produced the simplest structure, and both the three-factor and the four-factor solution could be considered acceptable. Confirmatory factor analysis of the extracted GHQ-20 factor model in both datasets (Twin1 & Twin2) indicated that the four-factor solution is superior to the three-factor solution.

Analysis of the subscale scores of the GHQ-20 by gender and demographic variables suggested that the factors are distinct. In all subscales females reported significantly higher levels of psychological distress than males, and for employment status the differences between employed and unemployed emerged for all four factors. More detailed results are presented in Study IV.

6 Discussion

Developmentalists from different theoretical orientations acknowledge that the quality of one-on-one interactions with significant others is crucial to children's social, emotional and cognitive growth. The substantive changes in adolescents' relationship with parents and peers make adolescence a fascinating period for research in human development. Characteristic for this period is the adolescents' increasing susceptibility to peer influence and decreasing susceptibility to parental and familial influences. One way of expressing independence from the parents is to rely more on peers or, in the case of twins, on one's co-twin. Thus, adolescent twins must gain independence from their parents, but also create a more independent and separate relationship with their co-twin (Siemon 1980).

Adolescence as a developmental phase forms an interesting framework for studying co-twin dependence and especially with respect to associations of dependence. Several factors of social functioning, psycho-emotional characteristics and health related behaviors were assessed in relation to co-twin dependence. The decision to use the concept of co-twin dependence was made partly in order to be consistent with the terminology used in previous research on twins, but also to be consistent with the questionnaire used in this study, in which twins were asked if they consider themselves dependent on their co-twin or not. However, in the present study, *co-twin dependence* might just as well have been called a strong "attachment" or "reliance" between twin siblings.

6.1 Main findings and consistency with previous research

Many clinical and qualitative studies as well as the popular literature have portrayed the twin relationship and the interaction between twin siblings to have unique characteristics. The present study provides evidence that the often referred dependence of twin siblings actually exists. Twins themselves report and acknowledge of being dependent on their co-twin. In this respect, the results of this study are consistent with those of previous clinical and qualitative findings. However, this study extends earlier findings in four important ways. First, co-twin dependence was explored in a highly representative population-based sample, which made it possible to estimate how distinctive a characteristic of the co-twin

relationship dependence is. Secondly, this study explores virtually unstudied associations of co-twin dependence with psychological and social domains. Thirdly, co-twin dependence was investigated both as an individual characteristic and as a dyadic characteristic of the twin pair. Co-twin dependence was predicted by the individual twin's own dependence, the perceived dependence of the co-twin, and the interaction and perceived reciprocity of these two. Fourth, the results obtained here support previous findings on gene-environment interaction on abstinence and on alcohol use and extend them by suggesting that close and intimate relationships in co-twins may mediate genetic influences on alcohol use. Also the fact that twins were residing together at the baseline extends earlier analyses on gene-environment interactions of older twins.

6.1.1 Prevalence and associations of co-twin dependence

Findings of this study suggest that co-twin dependence is a relatively common, but not a dominant or permeable characteristic of the co-twin relationship. It should be noted that most of the twins at age 16 in the present study did not consider themselves to be dependent on their co-twin. Thus, co-twin dependence should be considered as a characteristic of certain individuals and twin pairs, not as a fundamental characteristic of co-twin relationships in general. Most twin siblings may have a relationship which is comparable to any other relationship between siblings of approximately the same age. Consistent with findings of the few previous studies, the prevalence of co-twin dependence seemed to vary according to gender and twin type (Ainslie 1985, Fischbein *et al.* 1990, Neyer 2002b, Trias *et al.* unpublished). Females were more likely to report dependence than males and MZ twins were more likely to report dependence than DZ twins. Yet, as there were no significant differences between same-sex DZ and opposite-sex DZ twins, differences between experienced co-dependence cannot be attributed solely to twin type. Therefore, we cannot relinquish completely the idea that the co-twin relationship may have unique characteristics, since the strength of the relationship in opposite-sex pairs seems to transcend gender differences. On the other hand, this result raises the question of whether sibling relationships in general entail a certain level of dependence. However, comparisons between twins and singletons should be made with caution as the effect of siblings' age-spacing is evidently different in twins from that in singleton families. In singleton families the relationship between full siblings is by nature hierarchically constructed between an older and a younger sibling. Therefore their dependence might also be dynamically different and not similarly reciprocal as dependence can be in twins. Unfortunately these data could not be used to explore whether and to what extent the co-twin relationship might differ from twins' other sibling relationships or sibling relationships in general.

The gender differences in dependence found in all zygosity groups might be understood more generally in the light of gender roles. Different studies of male-female differences in psychological and personality characteristics have suggested that females are more likely to be attuned and more sensitive in their relationships and they are also more likely to express their feelings of closeness and affection compared to males (e.g. Dindia & Allen 1992, Eagly & Crowley 1986, Feingold 1994). Considering co-twin

dependence, it is relatively apparent that male subjects are less likely to report co-twin dependence. Also the connotations of dependence, such as immaturity and weakness (Ainsworth 1969, Lytton 1980), might have made male twins less disposed to report their dependence.

In general, mothers' reports of their twins' dependence were consistent with the twins' own reports. Mothers, were more likely to perceive their twins to be dependent at primary school age (age 7-12) than twins themselves at age of 16. It is likely that the co-twin dependence diminishes with age, as some studies have suggested (Trias *et al.* unpublished). Additionally, the use of different evaluations and raters of dependence, i.e. mothers' observations and twins' self-reports of experienced dependence, may explain the quantitative differences. Contrary to the twins' own reports, mothers' reports indicated no gender difference in dependence among MZ or same-sex DZ twins, and mothers were significantly more likely to evaluate boys in OSDZ twin pairs as dependent compared to their twin sisters. This might be accounted for by the faster development and earlier maturation of girls versus boys on average; mothers may have perceived the more matured girl twin also more independent. Earlier studies have suggested that, especially in opposite-sex pairs, female twins tend to play a socially active role in the twin dyad (Bryan 1992, Moilanen 1987), which might translate into observations that male twins are more dependent on their co-twin sister.

The associations of co-twin dependence were relatively consistent. In general, dependence was related to higher contact frequency and more intense social interactions between the two co-twins both in adolescence and in early adulthood. There were, however, zygosity differences in the associations, and the effects of dependence on twins' social interactions seemed to be stronger among dependent MZ twins. As associations of co-twin dependence have not been studied before, comparisons with the results of with previous studies are precluded. However, findings of this study suggest that the developmental environment may be relatively different for dependent and independent twins. This finding has also implications for studies of gene-environment interaction, because dependent twins evidently share their social environment to a greater extent than independent twins.

When co-twin dependence was analyzed in relation to twins' school attendance after compulsory education, it was found that the dependent twins, especially boys, had a greater tendency to remain outside the most common educational paths than non-dependent twins did. The trend in attaining a certain educational level suggested that independent twins were more likely to choose high school, whereas the vocational education group and those in the "other" group seemed to have a greater proportion of dependent twins, even though there were no differences in twins' academic achievements in general. Separation in adolescence may cause insecurity and an inclination to sustain the old dyadic behavioral patterns, which may lead to a desire or inclination to postpone educational choices and the selection of individual life course. A similar tendency was also seen in early adulthood, where dependent twins were more likely to reside with their co-twin and move apart at older age than independent twins.

Previous case and clinical studies have shown that different qualities in the co-twin relationship are associated with individual twins' psycho-emotional well-being, and studies of dependence in twin siblings have generally viewed the close and intensive relationship between twins rather as a developmental deficit, causing increased

psychological distress (e.g. Joseph 1961, Siemon 1980). The hypothesis of previous studies that the quality of the co-twin relationship may be associated with psycho-emotional symptomatology was supported in this study. Co-twin dependent twins reported significantly higher levels of psychological distress and somatic complaints in adolescence than co-twin independent twins. This finding may reflect the differences between dependent and independent twins in the relational shift and in transitions related to this developmental phase. In adolescence twins need to be sensitive to the fact that their relationship is changing, and this may impact the dynamic system of twinship dramatically. The separation-individuation process might cause additional stress to co-twin dependent twins, as subjective experiences of twinship and expectations of behaving as a dyad become an emotional issue. Additionally, the drive toward separation is opposed to feelings of dependence. Co-twin dependent twins may find it very difficult to balance their autonomy and dependency needs. Conclusions are also justified if co-twin dependent twins are more likely to have a shared identity (see Macdonald 2002). Adolescence in general is the developmental period when confusion and changes in identity are apparent (Marcia 1980) as the adolescents move away from childhood security to unknown challenges of the future. Usually this identity crisis is resolved and the new role is negotiated with relatively few difficulties. However, problems in identity development may in some cases cause increased psycho-emotional distress (e.g., Akhtar & Samuel 1996, Newman 2005, Remschmidt 1994).

Another plausible explanation for differences in psychological distress is that co-twin dependence may have characteristics and associations with mental health similar to those of interpersonal dependence (IPD) (Bornstein 1992). However, in this study the associations seemed to be transitional and to diminish towards adulthood, which contradicts the findings of IPD, for which associations with mental health are relatively consistent. Nevertheless, the results of this study suggest that the differences in co-twin relationships, in this case differences in co-twin dependence, are associated with differences in individual twins' social-emotional characteristics, especially in adolescence.

One starting point for this study was that co-twin dependence on one hand is a very personal and intimate experience of interdependence, and on other hand a pattern of dyadic interaction that might be mutually regulated and reciprocal. Therefore, co-twin dependence was explored and conceptualized both as an individual characteristic and as a dyadic characteristic of the twin pair. This approach made it possible to take into account the possibility that individual-based perceptions of dependence within a twin dyad may be substantially different than the views of the two co-twins of a twin pair when they are reporting only their own dependence. Most twin pairs (80.7%) were concordantly either co-twin dependent or co-twin independent. Concordance in dependence did not vary significantly among zygosity groups, however MZ males and females were more often concordantly co-twin dependent than DZ males and females. This finding provides support for the view that co-twin relationships are highly reciprocal (Winestine 1969). A similar and somewhat stronger point of view was taken by Neyer (2002b), who suggested that attachment security and dependency in twins should be conceptualized as characterizing a dyadic relationship rather than an individual person.

Another dyadic perspective which seemed to be important was individual twins' perception of concordance or discordance in dependency. According to this perspective

twins were categorized into four groups: *consonantly dependent*, *consonantly independent*, *dissonantly dependent* and *dissonantly independent* group. Most twins (71.5%) experienced their co-twin relationship as consonantly independent, i.e. one twin individual reported not being dependent and perceived his/her co-twin as also being non-dependent. Associations of these different categories with mental health were explored. The most vulnerable group seemed to be dissonantly dependent twins, who reported dependence for their own part, but viewed their co-twin as independent (n=174 twin individuals, 3.9% of subjects). These results suggested that each twin's unique experience of being mutually or one-sidedly dependent in their co-twin relationship may in some cases constitute a potential risk for psycho-emotional problems, especially for the dependent counterpart. It would also be interesting to study the associations of this dyadic interaction in relation to twins' social interactions and other characteristics and outcomes.

Co-twin dependence was studied in a gene-environment interaction framework in adolescence and in early adulthood. A relatively conservative test of gene-environment interaction was conducted by using twins' self-reports of abstinence, alcohol intake and intoxication frequency as outcome variables. This selection was made for methodological reasons, as a gene-environment interaction in the etiology of early-onset of alcohol use and alcohol use has received support from several previous studies (Dick *et al.* 2001, Koopmans *et al.* 1999, Maes *et al.* 1999, Rose *et al.* 1999). Nevertheless, the contribution of the co-twin relationship to the gene-environment interaction has not been studied previously.

The primary finding of this study was that while only few differences were found in prevalence of abstinence between dependent and independent twins and no effect of co-twin dependence on drinking or intoxication frequency, there were significantly higher pairwise resemblances in co-twin dependent twins for drinking behavior compared to independent twins. Another major finding in the present study was that the genetic contribution to individual differences in drinking patterns, especially in adolescence, is dependent on the nature of the pair-wise relationship. In other words, the impact of genetic liability was reduced as a function of co-twin relationship. Conversely, genetic influences on drinking habits were expressed among independent twins; especially in drinking frequency and in intoxication frequency genetic influences were as important as shared environmental effects. For co-twin dependent twins, their non-shared environment was less important than for independent twins, perhaps reflecting a greater overlap in the shared experiences of co-twin dependent twin pairs.

Findings of this study support the view, which has received more and more support in the field of behavioral genetics, that we inherit dispositions, not destinies. Life outcomes are not simple consequences of genetic consignments; rather they are consequences of a lifetime of behavior choices. The choices are guided by our dispositional tendencies, and these tendencies find expression within environmental opportunities (Rose 1995).

6.1.2 Co-twin dependence in the framework of attachment and dependency

Co-twin dependence seems to encompass characteristics of both attachment and dependency. Caution is, however, necessary when interpreting these results. Dependent twins' tendency to share and seek for each others' company, both in adolescence and also in early adulthood, could be interpreted as an effect of proximity seeking, which according to attachment theory is observable in such behaviors as approaching, staying near and staying in contact with the other. Similarly, in adolescence dependent twins' tendency to experience more distress in situations of separation could be interpreted in terms of attachment theory's separation protest. It can only be hypothesized that dependent twins are more likely to provide each other a safe haven, social support and comfort in times of stress. However, it is necessary to keep in mind that attachment in twin siblings as such was not measured in this study.

Previous studies have shown both attachment and dependency to have associations with mental health, dependency having more often negative outcomes. The fact that co-twin dependent twins reported significantly higher levels of psychological distress in adolescence than co-twin independent twins may indicate some connections between co-twin dependence and interpersonal dependency. However, with the approach of early adulthood, these associations were diminishing, which suggests that co-twin dependence does not have enduring characteristics or associations similar those that are often related to interpersonal dependency. Similarly, these findings suggest that dependence between twin siblings is not a behavioral risk factor for alcohol use. Thus is in contrast to results reported for interpersonal dependence in non-twins in the general population. Studies of non-twins have suggested that interpersonal dependence is strongly associated with various psychological disorders and substance abuse, including increased alcohol use (Bornstein 1992, Loas *et al.* 1994, Prescott *et al.* 1997). On the other hand, relatively small effect sizes between dependent and independent twins in this sample suggest that co-twin dependence may not be a similarly excessive form of dependency that could predispose to undermine close relationships and threaten individual well-being. It is also important to recall that the study sample was relatively young. Additionally, adolescence, where the associations between co-dependence and psychological distress were stronger, is the period when twins usually need to redefine their relationship and change their patterns of relating to each other. The higher distress in co-twin dependent compared to co-twin independent twins may reflect the differences in the separation-individuation process and developmental phase and not necessarily the maladaptiveness of co-twin dependence.

One caveat is that despite the consistency of the findings with the two theoretical frameworks attachment and dependency, this research was unable to determine whether co-twin dependence is an attachment-related or a dependency-related feature. At this point, these findings rather appear to support for both approaches. A more detailed assessment of the nature of co-twin relationship and dependence would have enhanced the present study.

6.2 Material and methodological considerations

The present report is based on the Finnish Twin Cohort Study (FinnTwin16), which comprises of five consecutive birth cohorts of Finnish twins born in the years 1975-1979. The data were collected through mailed questionnaires. The birth cohorts were identified from the Central Population Registry of Finland (CPR). A major strength of this study is the large population-based sample. The high response rates at the baseline and follow-ups (over 90%) make this study population highly representative. The baseline questionnaire included a survey of health habits and attitudes, a symptom checklist and questions about relationships with parents, peers and co-twin, which made it possible to study co-twin dependence in relation to different social-emotional and health related variables. In addition, a family questionnaire dealing with family medical history, twin pregnancy and delivery, the twin's early development, health and behavior, as well as with zygosity and the twin relationship, made it possible to study mother's perceptions of the co-twin dependence.

One immediate concern in twin studies is the possible misclassifications of zygosity. In a large population-based sample, zygosity determination based on blood-typing is costly and time-consuming. Zygosity is therefore determined from parental or twins' self-reports on twins' perceived similarity in appearance. Even though this type of zygosity determination has been found to be highly accurate when compared to diagnoses based on blood-typing (Rietveld *et al.* 2000), the possibility for misdiagnosis exists. In the present study, zygosity diagnoses were based on twins' self-reports of similarity. Due to large sample size it is, however, likely that the effect of potential misclassifications is relatively small.

Self-reports in general are known to produce some biases (Stone *et al.* 2000). As some participants may have a tendency to present themselves in a socially desirable way, it is likely that they underreport undesirable behaviors and characteristics and conversely overestimate desirable ones. This might also have affected the results of the present study, especially when measures of alcohol use and co-twin dependence are considered. Different studies have found that quantity and frequency of alcohol use are relatively commonly underestimated in mailed questionnaires compared to, e.g. daily alcohol intake diary or biochemical markers of alcohol intake, especially when the reference period requires a retrospective recall (Carlsson *et al.* 2003, Ekholm 2004, Townshend & Duka 2002). The accuracy of reports also seems to depend on the measurement instrument, e.g. whether the alcohol intake is reported as quantity-frequency or graduated-frequency (Poikolainen *et al.* 2002, Stockwell *et al.* 2004) as well as the population studied, e.g. high drinkers vs. young social drinkers (Townshend & Duka 2002). Nevertheless, it seems that the self-reports have a relatively good discriminative power to distinguish different groups of alcohol consumers (Carlsson *et al.* 2003). Considering the present study, the focus was on co-twins' similarity and dissimilarity on alcohol use, not in consumption quantity or frequency as such. It is likely that the reporting bias is consistent across the dataset and therefore in the present study the effect of reporting bias can be considered relatively small.

A similar reporting bias, i.e. tendency to underreport undesirable behaviors and overestimate desirable ones, might be possible in co-twin dependence. Being independent

obviously represents socially more desirable behavior (Ainsworth 1969, Lytton 1980), especially in males. Additionally, the fact that the self-report format gave relatively little liberty of choice concerning co-twin dependence might have had caused the vast majority of twins to consider themselves to be independent. The data on co-twin dependence were collected in self-reports of twins' own experienced co-twin dependence and twins' perception of their co-twins' dependence. Similarly mothers' reported on each twins' dependence separately. Multiple informants allowed a certain level of cross-validation, and the construct validity of co-twin dependence is supported by patterns in the results of the mothers' reports of dependence, as well as in the co-twins' evaluations of their own dependence and that of their co-twins. The responses of these three groups of informants are congruent and consistent. Nevertheless, an interview method for assessing co-twin dependence would have presumably given more reliable and detailed information about co-dependence, however conducting such interviews with over 5000 twin individuals would have been unreasonably time-consuming. The choice of self-reports for assessing dependence in twins was due to the nature and aim of the FinnTwin16 study, which was originally designed to study twins' development and health in a population-based sample.

Another limitation is that co-twin dependence was measured only in the baseline survey at age 16 years. Due to the cross-sectional measurement of dependence at only one point in time, it is possible that the dependence measured in adolescence is no longer relevant in early adulthood. This, in turn, might have diminished the power to detect associations of co-twin dependence in early adulthood. Still, the more frequent co-twin contact and higher relationship contentment of dependent twins in adulthood can be interpreted to reflect the continuation of dependence beyond adolescence. Additionally, twins were in the latter stages of their puberty when they filled in the questions concerning dependence, which is another possible source of bias. Adolescence is the period when the transition between childhood and adulthood occurs, and the urge to be independent and self-reliant emerges strongly. Alternatively, the transition process in adolescence may cause additional stress, which may enhance co-twin dependence and also affect the results.

A third factor that can be considered as a limitation is the cross-sectional nature of the data with respect to mental health outcomes. Although present analyses offer consistent evidence that co-twin dependence is associated with the mental well-being of twins, this evidence is not conclusive. Ideally, mental health problems should be assessed with the same measure at two different time points. This was not possible here. The use of different measures of psychological distress at the two different points in time precluded non-biased longitudinal comparisons. Additionally, more common and validated measurement instrument of mental distress in adolescence would have increased the interpretability of these results.

6.3 Implications for further research

Future research needs to build on the inherent limitations of this study. First, longitudinal research is needed in order to delineate more carefully the process that dependence evidently is. In this study co-twin dependence was assessed only at the baseline (age 16)

and it is likely that in early adulthood the prevalence of co-twin dependence would have been somewhat lower than in adolescence, as some authors have suggested (*Trias et al.* unpublished). It is relatively well established that, in general, development of sibling relationships follows a U-shaped curve. In childhood and adolescence sibling relationships are relatively close. Towards adulthood individuals begin to detach themselves from the family of origin, which usually affects the sibling relationships as well. From middle age onwards after the reproductive and generative period, siblings seem to re-establish their relationships and become closer again. Neyer (2002a) provided evidence that in this respect twin relationships are not very different from the relationships between singleton siblings. Therefore the possibility to measure co-twin dependence and its associations in different ages, developmental phases and points in time would be fascinating.

Another important aim for future studies is to explore more carefully the construct validity of the methodology employed here by applying qualitative methods along with quantitative data. Improvements in the measurement and analysis of data on self-reported co-twin dependence should be developed. In the present study co-twin dependence was assessed using a single-item measure at the baseline. It is to be hoped that future studies will corroborate these findings via multi-item scales and diverse methods. The greater affiliation and dependence between MZ than DZ twins should redirect attention to the proximal social processes underlying these differences. Even if co-twin dependence is measured specifically in a population of twins, the self-questionnaire might be preceded by questions about defined attachment figures besides the co-twin. The experienced dependency or attachment features could be measured in relation to the co-twin as well as to other attachment targets, such as twins' siblings, friends, spouses, and so on. Interview methods are, of course, well suited and sensitive for assessing these relationship qualities, but their usability in large population-based samples is limited for practical reasons. However, for behavioral genetic studies it is important that different dimensions of interpersonal relationships and co-twin relationship especially can be assessed easily with relatively simple but validated measures.

Yet another unanswered question is: what causes dependence in twins. Is dependence genetically driven, as Neyer (2002 a, b) suggested; or could it be seen from the evolutionary psychological perspective that affiliative feelings between close genetic relatives are endogenous, and a way of facilitating transmission of genes into future generations (Segal 2003); or could it be traced to the family environment and early relationships between twins? The family environment is not irrelevant for children's behavioral outcomes. Parenting differences (Goldberg *et al.* 1986, Loehlin & Nichols 1976, Robin *et al.* 1988) in infancy should be studied more carefully in relation to co-twin dependence but also in middle childhood and adolescence. Similarly, other contextual factors, such as perinatal morbidity, birth order or being preterm-full-term, may be associated with co-twin dependence (Alin Åkerman & Suurvee 2003, Moilanen 1988). Last but not least, it would be important to explore if co-twin contact induces dependence. Are the constant presence of the co-twin, the ongoing process of give and take, sharing thoughts and feelings, factors that promote real intimacy and dependence in twins, in other words the question is whether co-twin dependence is after all a *result* of twins' more frequent interaction, rather than a *cause*. Similarly, research is clearly needed to identify mediating processes entangled in measures of co-twin relationships in their

association with different psycho-emotional and behavioral outcomes. Efforts to extend the use of multivariate techniques into additional domains, involving other aspects of the co-twin relationship, might produce useful results.

Finally, more studies are needed to replicate these findings of a gene-environment interaction. This field of research would also of benefit from larger study populations. In early adulthood, the relatively small number of dependent twins, especially males, reduced the power of the test used here to detect differences in heritability of intoxication frequency. Therefore, expanding the databases in which developmental models can be tested is important. In future analyses, it would also be interesting to disentangle whether co-twin dependence has mediating effects on other behavior and health related outcomes, such as depression, anxiety, smoking, etc. Even though progress has been made in research design and analysis, different levels of analysis are needed within studies rather than always across them. The finding that twins' closeness and dependence are associated with genetic liability for alcohol use is compelling. Convergence of results from studies using other genetic designs, samples, ages, measures and approaches is clearly needed.

6.4 Conclusions

All in all, it is important to stress that for the first time co-twin dependence has been reviewed here in a large and highly representative population-based sample of twins, with an excellent response rate. The data derived from FinnTwin16 made it possible to compare gender and zygosity differences in dependence. Moreover, this broad longitudinal survey of development, health and lifestyle of twins facilitated an analysis of long-term causes and consequences of the twin relationship and co-twin dependence.

Although the results of the present study do not produce direct proof of the influence of co-twin dependence on twins' developmental or social-emotional adjustment, they clearly show the importance of the inter-twin relationship in each individual twin's life. As part of their "birthright", twins are constantly forced to share, compete, and take each other into consideration in their daily lives. The family environment, including sibling relationships, has strong impact on children's development and behavioral outcomes.

Methodologically, findings of the present study suggest that studies of gene-environment correlations would benefit by examining processes whereby intimate dyadic and inter-personal relationships may translate into altered behavioral /phenotypic outcomes. The results reported here suggest that the existence of fundamentally different qualities of the twin relationship should be taken into account when psycho-social and behavioral traits are studied in twins. Identifying the processes underlying these full interpersonal relationships may enhance our understanding of many complex human social behaviors. We might, for example, better comprehend why some family members are more closely affiliated and influenced by each others behaviors, while others are not.

Fortunately, Finntwin16 is a rich and ongoing longitudinal study. It provides data continuously and inspires researchers to find and develop new approaches that will help us understand co-twin dependence and its impact on the development and life trajectories of twins.

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Original publications

- I Penninkilampi-Kerola V, Moilanen I, Kaprio J. (2005) Co-twin dependence social interactions and academic achievement – A population-based study of adolescent twins and their parents. *Journal of Social and Personal Relationships*, 22, 519-541.
- II Penninkilampi-Kerola V, Kaprio J, Moilanen I, Ebeling H, Rose RJ. Co-twin dependence, personality and mental health – A population-based study of Finnish twins. *Twin Research and Human Genetics*, submitted.
- III Penninkilampi-Kerola V, Kaprio J, Moilanen I, Rose RJ. (2005) Co-twin dependence modifies heritability of abstinence and alcohol use: A population-based study of Finnish twins. *Twin Research and Human Genetics*, 8, 232-244.
- IV Penninkilampi-Kerola V, Miettunen J, Ebeling H. A comparative assessment of the factor structures and psychometric properties the GHQ-12 and the GHQ-20 based on data from a Finnish population-based sample. *Scandinavian Journal of Psychology*, in press.

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