Male brain type women and female brain type men:
Atypical cognitive styles and their correlates

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Goals: Gender differences have been found in terms of e.g. certain abilities and interests, and working life remains partially segregated based on gender. According to the empathizing-systemizing theory, the reason for all gender differences lies in average differences in cognitive styles: women have been found to empathize more, which is useful in understanding people, while men have a stronger tendency to systemize, which means interpreting different phenomena as rule-based systems. The term “male brain type” refers to a heightened tendency to systemize, while “female brain type” means a tendency to empathize. Prior research has not addressed the people who do not fit these typical brain types: male brain type women and female brain type men. The goal of this study was to find out whether male brain type women have other qualities more typically associated with men, and whether female brain type men have other qualities typically associated with women. The qualities investigated were occupational or educational field, parents’ occupational fields, school grades in physics and mathematics, hobbies, cognitive empathic ability, social connectedness, and sex role identity.
Method: 3084 people participated in an online study consisting of surveys and tests. Female and male brain type groups were identified among both male and female participants. Comparisons between the groups were conducted for both genders, and the predictive values of the different qualities in terms of brain type were investigated through logistic regression analysis.
Results and conclusions: Differences were found in the majority of the comparisons between the male and female brain type groups in both sexes. Female brain type men exhibited more qualities typically associated with empathizing or femininity than did male brain type men, and male brain type women exhibited more qualities typically associated with systemizing or masculinity than did female brain type women. The largest differences were seen in social connectedness and female sex role identity. The results show there are male brain type women and female brain type men, who are characterized by qualities more often associated with the opposite sex, and who have not been reached by prior research and commonly conducted comparisons between men and women. Instead of looking for average sex differences, a more fruitful direction for research may be investigating differences between the brain types.

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brain type, empathizing, systemizing, cognitive style, gender differences

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Miesaivotyyppiset naiset ja naisaivotyyppiset miehet: epätyypilliset kognitiiviset tyylit ja niiden korrelaatit

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Tiivistelmä – Abstrakt – Abstract

Tavoitteet: Naisten ja miesten välillä on löydetty eroja muun muassa tiettyjen kykyjen ja kiinnostuksen kohteiden suhteen, minkä lisäksi esimerkiksi työmarkkinat ovat jakautuneet naisten ja miesten aloihin. Empatisointi-systemointi -teorian mukaan sukupuolierojen syynä ovat naisten ja miesten keskimääräiset erot kognitiivisissa tyyleissä: naisten on todettu käyttävän enemmän empatisointia, joka auttaa ymmärtämään ihmisten toimintaa, kun taas miehillä on korkeampi taipumus systemoida, eli tulkita ilmiöitä sääntöperustaisina järjestelminä. Termi "miesaivotyyppi" viittaa korostuneeseen systemointitaipumukseen, kun taas "naisaivotyypillä" tarkoitetaan korostunutta empatisointitaipumusta. Aiemmin ei ole tutkittu ihmisiä, jotka ovat epätyypillisiä tämän tyyppijaon suhteen: miesaivotyyppisiä naisia ja naisaivotyyppisiä miehiä. Tämän tutkimuksen tavoitteena oli selvittää, onko miesaivotyyppisillä naisilla naisaivotyyppisiä naisia enemmän muitakin ominaisuuksia, jotka tyypillisesti yhdistetään miehiin, ja onko naisaivotyyppisillä miehillä miesaivotyyppisiä miehiä enemmän ominaisuuksia, jotka tyypillisesti yhdistetään naisiin. Vertailtavia ominaisuuksia olivat ammatti- tai opiskeluala, vanhempien ammattialat, fysiikan ja matematiikan kouluarvosanat, harrastukset, kognitiivinen empatiakyky, sosiaaliset yhteydet, ja sukupuolirooli-identiteetti.
Menetelmät: 3084 hengen kysely- ja testiaineisto kerättiin e-lomakkeella. Nais- ja miesvastaajista määritettiin mies- ja naisaivotyyppiryhmät. Näitä ryhmiä verrattiin kummankin sukupuolen kohdalla toisiinsa tutkimuksen kohteena olevien ominaisuuksien suhteen, ja ominaisuuksien ennustearvoa aivotyypin suhteen tutkittiin logistisella regressioanalyysilla.
Tulokset ja johtopäätökset: Nais- ja miesaivotyyppiryhmät erosivat toisistaan valtaosassa sekä naisten että miesten vertailuista. Naisaivotyyppisillä miehillä oli enemmän empatisointiin tai feminiinisyyteen yhdistettäviä ominaisuuksia kuin miesaivotyyppisillä miehillä, ja miesaivotyyppisillä naisilla oli enemmän systemointiin tai maskuliinisuuten yhdistettäviä ominaisuuksia kuin naisaivotyyppisillä naisilla. Suurimmat erot löytyivät sosiaalisten yhteyksien sekä feminiinisen sukupuoli-identiteetin suhteen. Tulokset osoittavat, että on olemassa miesaivotyyppisiä naisia ja naisaivotyyppisiä miehiä, joita luonnehtivat useat vastakkaiseen sukupuoleen yhdistetyt ominaisuudet, ja joita aiempi tutkimus ja tyypilliset sukupuolten väliset vertailut eivät ole tavoittaneet. Keskimääräisten sukupuolierojen tutkimisen sijaan voikin olla hedelmällisempää tutkia aivotyyppien välisiä eroja.

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aivotyyppi, empatisointi, systemointi, kognitiivinen tyyli, sukupuolierot

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1. Introduction

It is often proposed that men and women think differently or have different ways of perceiving and making sense of things. Gender differences and their underlying causes are frequent topics of research as well. In this study, focus is placed on “male” and “female” cognitive styles and their connections to other constructs typically associated with men and women, or masculinity and femininity.

The social constructs of masculinity and femininity are quite well understood as collections of assumed attributes relating to men and women – for example, femininity is commonly associated with emotions and masculinity with logic. In addition to personal qualities, femininity and masculinity are perceived to entail, for example, different sets of skills, interests, and vocations (see e.g. Baron-Cohen, 2002; Baron-Cohen, 2003; Nettle, 2007). Higher value is often ascribed to masculine attributes compared to feminine ones (Ely & Meyerson, 2000). The influence of socially prescribed, gender-based norms and expectations is a widely researched topic, but the kinds of cognitive structures that could – either independently or perhaps as a result of social influences – play a role in observable gender differences are not yet very well understood.

Gaining more information concerning gender-dependent cognitive phenomena can develop our view of how gender-related social phenomena are created. For example, despite strides in equality, a gender-based division still exists among occupational fields. Traditionally, men have worked in the fields of science, technology, engineering, and mathematics (STEM), and women have been the majority in the people-focused areas of working life. This division is seen in statistics in numerous countries. In the USA, even though the proportion of academic degrees awarded to women has risen in the past decades, women’s representation is still the lowest in engineering, computer sciences, and physics, and women earn approximately one fourth of the doctorates in mathematics and statistics (National Science Foundation, National Center for Science and Engineering Statistics, 2015). Also in Finland, the division between men’s and women’s occupations is still clear: about three times more women than men are occupied as sales and service workers, and men outnumber women even more drastically in occupations such as construction, manufacturing, and transport (Official Statistics of Finland, 2009).

Different explanations have been offered for this phenomenon where men are more likely to work in the STEM fields and women with people. Often, it is seen as the result of either inborn preferences or socially constructed gender norms. A recent study suggests that a combination of masculine cultures, lack of early experience with topics such as engineering and physics, and gender gaps in self-efficacy explain why women are more underrepresented in some STEM fields than in others (Cheryan, Ziegler, Montoya, & Jiang, 2016). Even though our understanding of psychology has grown and society has become more flexible regarding gender norms, there are likely to still be unidentified structures underlying phenomena such as the significant gender segregation in working life. New approaches that go beyond the superficial level of biological sex and address cognitive structures have been called for (Lai et al., 2012). Further increasing our understanding is crucial for both scientific and practical reasons: knowledge of these issues guides the efforts and social policies designed to increase equality in different areas of life, such as employment and education.

The study at hand aims at increasing our understanding of gendered phenomena by investigating specific cognitive styles in which gender differences have been identified. This will be accomplished by focusing on groups of people who differ from the cognitive style typically associated with their gender, and exploring different aspects of their psychological profiles. As this research will specifically focus on cognitive styles, it is important to distinguish the concept of cognitive style from that of cognitive ability. Cognitive style refers to the way in which an individual typically makes sense of different phenomena, and among other methods, this can be assessed through self-evaluation measures. As opposed to cognitive style, the concept of cognitive ability refers to an individual's optimal level of performance, which cannot be reliably assessed using self-evaluation.

The cognitive styles researched here are *empathizing* and *systemizing*, which have been associated with women and men, respectively (Baron-Cohen, 2002; Baron-Cohen, 2003; Baron-Cohen, Knickmeyer, & Belmonte, 2005). More specifically, the topic of this study is whether women exhibiting a cognitive style typical of men (systemizing) have other qualities typically associated with men; and similarly, whether men exhibiting a cognitive style typical of women (empathizing) have other qualities that are more often associated with women.

1.1 Gender differences in components of cognitive ability

Cognitive abilities have been widely researched in order to identify sources of gender differences. While the main focus in this study is on cognitive style, there are some relevant gender differences in specific components of cognitive ability that appear to be related to the cognitive styles investigated here. When discussing cognitive gender differences, it is important to note the nature of those differences as well as their limits. Comparisons of men and women at the population level find no evidence of gender differences in general intelligence (Halpern & LaMay, 2000). However, sex differences have been identified in specific components of cognitive ability. For the purposes of this study, the most relevant sex differences will be ones concerning systematic, physical-mathematical reasoning and those in social-emotional abilities.

The largest and most consistent gender differences have been found in spatial ability (Halpern, Straight, & Stephenson, 2011). Men, on average, perform better than women in visual-spatial ability, which is likely to be related to the male advantage in solving mathematical problems (Halpern & LaMay, 2000). Men also score higher on engineering and physics problems (Lawson, Baron-Cohen, & Wheelwright, 2004). The differences in spatial ability have been found in large, cross-cultural studies (Peters, Lehmann, Takahira, Takeuchi, & Jordan, 2006; Silverman, Choi, & Peters, 2007) and confirmed in reviews of studies (Linn & Petersen, 1985; Voyer, Voyer, & Bryden, 1995). Women, on the other hand, perform better in tests of social sensitivity (McClure, 2000; Baron-Cohen et al., 2005), empathizing (Baron-Cohen & Wheelwright, 2004), and memory and language skills (Halpern & LaMay, 2000; Silverman et al., 2007; Reynolds, Scheiber, Hajovsky, Schwartz & Kaufman, 2015), among other differences (for a more comprehensive list of sex differences, see Baron-Cohen et al., 2005).

While there is converging evidence for the existence of these sex differences, it is important to remember that the effect sizes vary significantly and are typically quite small: for example, gender alone explains only a relatively small proportion of individual variation in spatial ability (Caplan & Caplan, 1994), and the genders are more similar than different (Reynolds et al., 2015). In addition, while some average differences are known to exist, the reasons why they exist and the potential underlying structures, whether they be biological or social, are not fully understood.

The focus of the current research will be investigating potential associations between gender-atypical cognitive styles and gendered cognitive abilities and other qualities: are women with a cognitive style typical of men more likely to display other abilities and attributes more often associated with men, and are men with a cognitive style typical of women more likely to have abilities and other qualities more often associated with women?

1.2 Systemizing and empathizing as the essential difference

Baron-Cohen (2003) has proposed the “empathizing-systemizing” theory as an explanation for psychological sex differences. According to this theory, differences in empathizing with others and systemizing abstract rules that govern how things operate create gender differences. Importantly, the theory states that empathizing and systemizing are not merely psychological dimensions that correlate with certain other attributes, but rather they are the fundamentally significant cognitive dimensions that comprise and define the essential difference between men and women.

Empathizing is defined as the “drive to identify another person’s emotions and thoughts, and to respond to these with an appropriate emotion” (Baron-Cohen, 2002, p. 248). This allows a person to predict human behavior and care about others’ feelings. Empathizing covers the concepts of theory of mind as well as both empathy and sympathy. Baron-Cohen uses the term in a meaning that is similar to the more frequently used “empathy”. Empathy refers to the reactivity of an individual to the observed experiences of another, which includes both affective and cognitive components (Davis, 1983). More specifically, empathy has been described as the hard-wired, natural ability to understand the emotions and feelings of others, whether these emotions are witnessed directly, seen in a photograph, or simply imagined (Decety & Jackson, 2014). There is evidence that on average, women empathize to a greater degree than do men (Baron-Cohen, 2002).

Systemizing is “the drive to analyse the variable in a system, to derive the underlying rules that govern the behavior of a system” (Baron-Cohen, 2002, p. 248). A system is defined as anything that takes inputs and delivers outputs. Systemizing, therefore, is the use of “if-then” rules, correlations, and inductive reasoning in understanding a variety of phenomena

(Baron-Cohen, 2002; Baron-Cohen, 2009). There is evidence that on average, men spontaneously use systemizing more than do women (Baron-Cohen, 2002). For example, Nettle (2007) has found that men have an average advantage in systemizing of approximately one half to one standard deviation when compared to women.

Both systemizing and empathizing allow us to make sense of events and form reliable predictions, but in other respects, they are almost each other's opposites (Baron-Cohen, 2002). They are also assumed to depend on independent regions in the brain, which is supported by some recent findings suggesting connections between systemizing and empathizing and certain neuroanatomical features (Lai et al., 2012). Systemizing and empathizing are useful in different contexts. Systemizing allows one to predict the behavior of a system; it works for lawful, finite, deterministic phenomena and is the most powerful way of understanding and predicting the law-governed inanimate universe. Empathizing, on the other hand, is the most powerful way of understanding and predicting the social world and human behavior. Systemizing is of almost no use in predicting moment-by-moment changes in human behavior, whereas empathizing has very limited use in predicting the behavior of systems (Baron-Cohen, 2002; Baron-Cohen, 2009). Because of this, differences in systemizing and empathizing may lead to different ability structures, which vary in usefulness among different situations and occupational fields.

While Baron-Cohen (2002) sees systemizing and empathizing as the core difference between the sexes, other factors may play a role in some gendered phenomena. In fact, Baron-Cohen (2009) explains men's greater representation in the STEM fields as a property of the normal distribution: variation in relevant skills is greater among men than it is among women, and therefore men far outnumber women in the extremes of the distribution despite the difference between averages being small. This would explain the disproportionate number of high-performing men in fields where systemizing is highly relevant. Other research has suggested that there are personality differences that are not explainable within the systemizing-empathizing framework (Nettle, 2007). While the systemizing-empathizing theory may not provide a comprehensive explanation for all gendered phenomena, it is nevertheless an interesting candidate as a major contributor to observed sex differences.

1.3 The male brain type and the female brain type

The concept of brain type, as it is used here according to Baron-Cohen (2002), refers to the relative weight of the two key dimensions, empathizing and systemizing, in an individual's characteristic way of understanding and making sense of things. We all have both systemizing and empathizing skills, but for some individuals, empathizing is more developed than systemizing, and for some, systemizing is more developed than empathizing. The relative development of empathizing and systemizing leads to five identifiable, broad categories, or brain types: (1) the female brain, where empathizing is more developed than systemizing; (2) the male brain, where systemizing is more developed than empathizing; (3) the balanced brain, where both are equally developed; (4) the extreme female brain, where empathizing is hyper-developed and systemizing hypo-developed; and (5) the extreme male brain, where systemizing is hyper-developed and empathizing hypo-developed.

The concepts of "male brain" and "female brain" are used to refer to these relative differences in the drives to empathize and systemize because more males than females have the systemizing brain type, and more females than males have the empathizing brain type (Baron-Cohen, 2002). It is important to note that Baron-Cohen (2002) does not suggest a categorical difference between men and women, or that all men have the male brain type and all women the female brain type. His central claim involves average differences: more men than women have the male, systemizing brain type, and more women than men have the female, empathizing brain type. Therefore, the terminology refers not to strictly sex-dependent differences, but to the processing modes typically associated with and more often found in men and women.

The reasons why an individual develops a male or female brain type may lie in both socialization and biology. While it seems likely that culture and socialization exert some influence on brain type, biology appears to be an important determinant. Average sex differences in interest toward social and physical-mechanical objects are present very early in life, which suggests a biological basis for the brain types (Connellan, Baron-Cohen, Wheelwright, Batki, & Ahluwalia, 2000). Nettle (2007) suggests that empathizing abilities may have preceded systemizing in our evolutionary history and been crucial for females' survival because of their need to nurture the young and their dependence on social alliances, whereas systemizing may have provided greater advantage for males, either due to their ability to use time for such innovative activity or because mastering, for example, different hunting technologies could improve their social status.

Systemizing and empathizing are often assessed using the Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004) and Systemizing Quotient (SQ; Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003), which are self-report measures of autistic traits. The concepts of systemizing and empathizing stem from autism research, and therefore, previous research has largely focused on individuals with autism spectrum disorder (ASD). According to the extreme male brain theory of autism, first suggested by Hans Asperger (as cited in Baron-Cohen, 2002), ASD represents a manifestation of the extreme male brain type (Baron-Cohen, 1995; Baron-Cohen, 2002; Baron-Cohen, 2003; Baron-Cohen, 2007). It has been shown that girls perform better than boys on "theory of mind" tests, which are related to empathizing ability, and children with autism or Asperger syndrome perform worse than normal boys (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997). The extreme male brain type has also been referred to as mind-blindness to describe the hypo-developed empathizing skills associated with ASD (Baron-Cohen, 2002). Due to their utilization mostly in ASD-related research, our understanding of the brain types as they are exhibited within the normal population remains limited.

As opposed to the extreme male brain type, the extreme female brain type, or "system-blindness", was not originally connected with any particular disorder (Baron-Cohen, 2002), and it has not been the direct focus of research as often as the male brain type. However, more recently the extreme female brain type has been associated with schizophrenia (Crespi & Badcock, 2008). In a non-clinical context, it has been suggested that empathizing is similar to the trait of agreeableness in the five-factor model of personality (Nettle, 2007).

An area that has not yet been studied is the question of atypical brain types: women with a male brain type and men with a female brain type. Here, these less typical brain types (male brain type women and female brain type men) will be referred to as "opposite brain types", as opposed to the "typical brain types" (female brain type women and male brain type men). Investigating how gendered skills and interests correlate with the male and female brain types in this context could shed more light on how gendered phenomena are structured, whether there could be larger structures underlying the observable gender-based differences, and what qualities characterize these previously unresearched opposite brain types. Therefore, this study will focus on the opposite brain types and their correlates.

1.4 Known gender differences

Sex differences in various abilities and qualities have been widely researched. As a comprehensive study on all aspects of such differences would be impossible to conduct, this study uses a selection of areas in which gender differences have been identified in order to compare the typical and opposite brain types with each other. These areas of focus include educational or occupational choices, hobbies, empathic ability, social connectedness, and gender identity. The goal is to investigate whether male brain type women differ from the more typical female brain type women, and similarly, whether female brain type men differ from the typical male brain type men in these areas.

1.4.1 Educational and occupational fields

As discussed above, there remains a distinct division between “women’s jobs”, which are typically people and service oriented, and “men’s jobs”, such as work in the STEM fields. Men have been found to have a preference for working with things, while women prefer working with people (Su, Rounds, & Armstrong, 2009), suggesting possible connections to systemizing and empathizing. Prior research indicates that there is a connection between an individual’s cognitive style and his or her choice of occupational field. A study by Billington, Baron-Cohen, and Wheelwright (2007) investigating students’ cognitive profiles and choice of educational field found a systemizing profile to be associated with studying physical sciences, and an empathizing profile to be more common among humanities students. While men, on average, show stronger systemizing and women show stronger empathizing, this finding suggests that the cognitive styles of systemizing and empathizing may explain educational choices better than biological sex alone.

As systemizing has been researched in the context of ASD, the hyper-systemizing characteristic of autism has been connected to success and interest in certain fields. In a recent study utilizing a self-report measure of autistic traits, the Autism Quotient, males scored higher than females, and individuals working in the STEM fields scored higher than did individuals employed in other fields (Ruzich et al., 2015). Another recent study suggests that the systemizing self-assessment measure SQ captures, in part, interests in the STEM fields (Byrd-Craven, Massey, Calvi, & Geary, 2015). In addition, systemizing as a cognitive style predicts not only performance but also interest in science, technology, computers, and the natural world (Nettle, 2007).

Associations between systemizing, or autistic traits, and occupational interests appear to extend to family members. There is a higher rate of autism in the families of persons who are talented in fields such as mathematics, physics, and engineering, compared with those talented in the humanities (Baron-Cohen et al., 1998). In addition, the fathers and grandfathers of individuals with autism, compared to the fathers and grandfathers of other individuals, have been found to be more than twice as often in occupations such as engineering (Baron-Cohen, Wheelwright, Stott, Bolton, & Goodyer, 1997). On one hand, these kinds of occupations require systemizing, and on the other, a degree of impairment in empathizing would not be a significant hindrance to success. These findings also suggest that autism, that is, the extreme male brain type, is at least to some degree inherited.

The studies described above raise the question whether observed gender differences in occupational and educational choices are related simply to gender, or perhaps also to brain type. If success and interest in fields requiring systemizing is related to the male brain type, then male brain type women should exhibit more success and interest in these areas than female brain type women. Likewise, if skills and interest in empathizing-related fields are associated with the female brain type, then female brain type men should exhibit these qualities more than male brain type men. It is also hypothesized that the male brain type is associated with parents who work in systemizing-focused fields, and similarly, that the female brain type is associated with parents occupied in empathizing-focused fields.

1.4.2 Hobbies

In addition to career-related choices, hobbies appear to be gendered as well. Previous research by Twenge (1999) shows that women, on average, have stronger esthetic interests while men have stronger interests in technology. Activities such as team sports, electronics, chess, computers, repairing things, and video games were endorsed more often by the male participants of the study, while the female participants chose hobbies such as talking to friends, aerobics, sewing or knitting, dancing, going to clubs, and shopping. Another study found men to have more realistic and investigative interests, while women preferred artistic and social ones (Su et al., 2009).

It should be noted that while systemizing and empathizing are interesting aspects to study also in this context, cognitive styles are unlikely to be the only factors influencing interest in different hobbies: for example, the greater female interest in esthetics cannot necessarily be explained simply as a matter of greater empathizing or lower systemizing tendencies (Nettle, 2007). However, in this study, it is hypothesized that on average, individuals exhibiting the opposite brain types will have hobbies that differ from those of the individuals exhibiting the typical brain types. If the male brain type is associated with masculine hobbies and the female brain type with feminine hobbies in both genders, this would indicate a connection between empathizing or systemizing and hobbies typically seen as feminine or masculine, respectively.

1.4.3 Cognitive empathic ability and social connectedness

As emotional and social abilities are typically connected with femininity and empathizing, and the lack of those abilities is associated with the male brain type and systemizing, these qualities constitute another interesting topic for this study. Previous research has found sex differences in the focus on quality of social relationships, or the connectedness and empathy within relationships, with women typically scoring higher than men on these measures (Baron-Cohen & Wheelwright, 2004).

Nettle (2007) found high scores in empathizing to be associated with more social support and with the maintenance of slightly larger numbers of social relationships. In addition, the study indicates that women score about 1.5 standard deviations above men on empathizing, and men score approximately 0.5–1 standard deviations higher than women on systemizing. This kind of attention to the needs and situations of others is also central to the agreeableness dimension of the five-factor model of personality; there is an interesting overlap between empathizing and agreeableness, which suggests a common contributor (such as prenatal androgen levels; see Nettle, 2007). Whereas empathizing appears to be closely related to agreeableness, systemizing may be more closely associated with specific aspects of intelligence than any personality trait.

There is reason to raise the question of whether the typical sex differences in social skills and connectedness are related to brain type rather than only biological sex. A recent study (Baron-Cohen et al., 2015) found no typical sex difference in cognitive empathic ability between men and women with autism, who all exhibited the extreme male brain type. If brain type is associated with cognitive empathic ability and social connectedness also within the normal population, there will be differences between the male and female brain types within each sex. Based on the findings described above, it is hypothesized that in both genders, the empathizing, female brain type will be associated with increased social connectedness and empathic ability when compared to the systemizing, male brain type.

1.4.4 Sex role identity

One possible factor contributing to observed sex differences is sex role identity. Sex role identity has been classically defined as an acquired self-concept of an individual's degree of masculinity or femininity (Kagan, 1964), and it has been found to influence the development of same-sex-typed attributes (Storms, 1979). Already Milton (1957) has suggested that average differences in problem-solving skills may not be based on biological sex, but rather related to individual gender identity types: a higher degree of masculine identity was associated with a higher level of problem-solving skills. A meta-analysis of 12 studies by Reilly and Neumann (2013) similarly shows that gender roles have predictive validity for the development of spatial ability, as masculine gender roles were found to be associated with increased spatial ability. This meta-analysis found a connection between masculine gender identity and mental rotation that had an effect size exceeding those of several other factors known to influence spatial ability. These studies suggest that gender-related differences, in particular cognitive skills, may be related to sex role identity. It is possible that these processes are associated with certain kinds of information processing and interpretation styles – including systemizing and empathizing. Therefore, it is hypothesized that the male and female brain types are connected to sex role identity: male brain type groups are expected to score higher in masculinity and lower in femininity than female brain type groups, and likewise, female brain type groups are expected to score higher in femininity and lower in masculinity than male brain type groups.

1.5 Goals and hypotheses

The present study investigates gendered phenomena specifically by focusing on cases of gender-atypical, “opposite” brain types: women who fit a ”male-brain” cognitive profile and men who fit a ”female-brain” cognitive profile. Participants will be studied from several perspectives: school performance in mathematics and physics, occupational field, parents’ occupational focus, cognitive empathic ability and social connectivity, hobbies, and sex role identity. By studying individuals representing the opposite brain types, this study strives to increase our understanding of individual and sex-based differences in cognitive qualities through adopting a new perspective on the subject. The expected finding is that the individuals representing the opposite brain types will differ from the individuals representing the typical brain types of their own gender, with the male brain type being associated with masculine qualities and the female brain type being associated with feminine qualities in both genders.

Based on the existing research on systemizing and empathizing described above, the following hypotheses are proposed:

Compared to female brain type women, male brain type women

H1	more often work in occupations with a focus on systemizing or things
H2	more often have parents who work in technical fields and less often parents whose work focuses on people
H3	have received higher grades in mathematics and physics
H4	have more hobbies that are typically considered to be masculine and/or fewer hobbies considered to be feminine
H5	have lower cognitive empathic ability
H6	are less socially connected
H7	have a gender role identity higher in masculinity and/or lower in femininity

Compared to male brain type men, female brain type men

H8 more often work in occupations with a focus on empathizing or people

H9 more often have parents whose work focuses on people and less often parents who work in technical fields

H10 have received lower grades in mathematics and physics

H11 have more hobbies that are typically considered to be feminine and/or fewer hobbies considered to be masculine

H12 have higher cognitive empathic ability

H13 are more socially connected

H14 have a gender role identity higher in femininity and/or lower in masculinity

2. Method

2.1 Participants and procedure

The participants were 2983 Finnish volunteers (65% female) who were recruited from internet discussion forums, student mailing lists, and a volunteer participant pool consisting of individuals who had expressed an interest in participating in studies. Their mean age was 28 years (*SD* = 8.87, range 15–69). Of the participants, 27% were working, 64% were students, and 9% were otherwise occupied. The majority of the students (85%) were university students; others were polytechnic (7%), vocational school (4.5%), upper secondary school (3%), and grammar school (0.5%) students. In terms of level of education, 7% of the respondents had a primary school education, 56% upper secondary school and/or vocational school education, 37% a polytechnic and/or university degree, and 1% a doctorate degree.

The messages sent out to internet forums and mailing lists included a hyperlink to the online questionnaire. Participants were informed that the study concerned thinking and personality. They were given 3 weeks to fill in the survey, by either filling the entire survey in one sitting or saving their responses and continuing later. As compensation for their effort, all participants received a thinking style profile based on the Actively Open-Minded Thinking Scale (Stanovich & West, 1997), which was included in the full survey.

Of the 3086 people who originally participated in the study, 105 were excluded. 2 participants were removed because their comments revealed that they had not completed the survey seriously. Many participants did not respond to all of the scales necessary for determining their brain type, possibly due to the length of the survey (the survey included tasks and scales not reported here). Sum variables for scales were not calculated for participants who had 25% or more missing items on a scale. The missing information resulted in the loss of 103 participants. In addition, 20 submissions were deleted, as they were perfect duplicates of another submission and likely had resulted from respondents saving their responses multiple times.

2.2 Measures

2.2.1 Empathizing and systemizing

As a self-evaluation measure of empathizing, the short, 15-item version of the Empathy Quotient (EQ) scale was used (Muncer & Ling, 2006; for the original 60-item scale see Baron-Cohen & Wheelwright, 2004). The EQ-Short measures cognitive empathy, social skills, and emotional reactivity (e.g. “I really enjoy caring for other people”). The original scoring method was used, whereby the 4-point response scale (1 = *strongly disagree*, 2 = *slightly disagree*, 3 = *slightly agree*, 4 = *strongly agree*) was converted into scores of 0, 0, 1, and 2. The sum of these scores was then calculated. Because the final score consisted of the sum of all responses on the scale, any missing values would have considerably affected the variable or decreased the sample size available. Therefore, cases with less than 25% of the answers missing were accounted for by determining each participant’s average score and multiplying it with the number of items on the scale, thereby forming an approximated sum variable. The reliability (Cronbach’s α) of the measure was .81. The distributions of the EQ variable are presented in Figure 1 (women) and Figure 2 (men), and related descriptive statistics in Table 1.

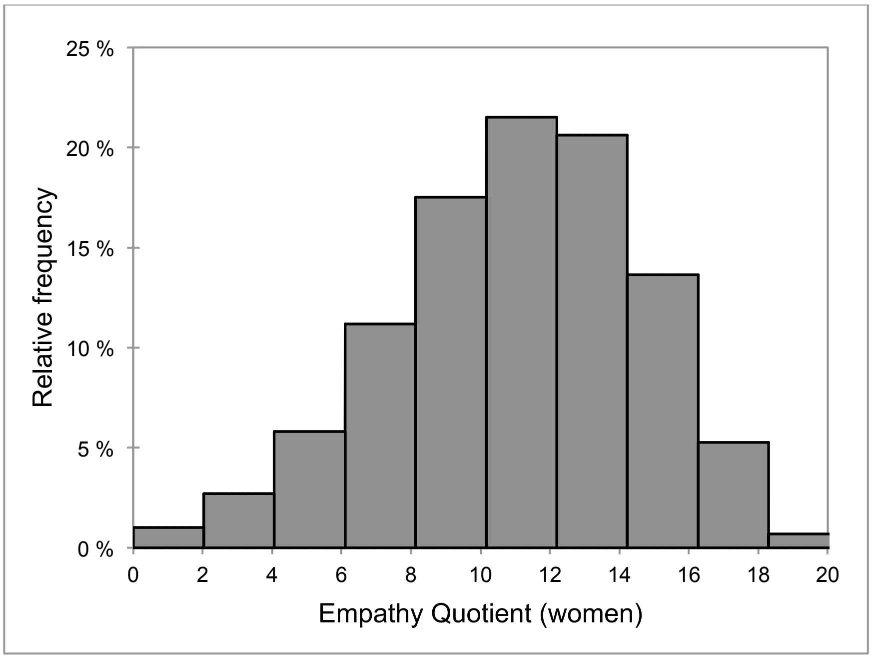

Figure 1. Distribution of the Empathy Quotient (range = 0.00, 19.33) for women.

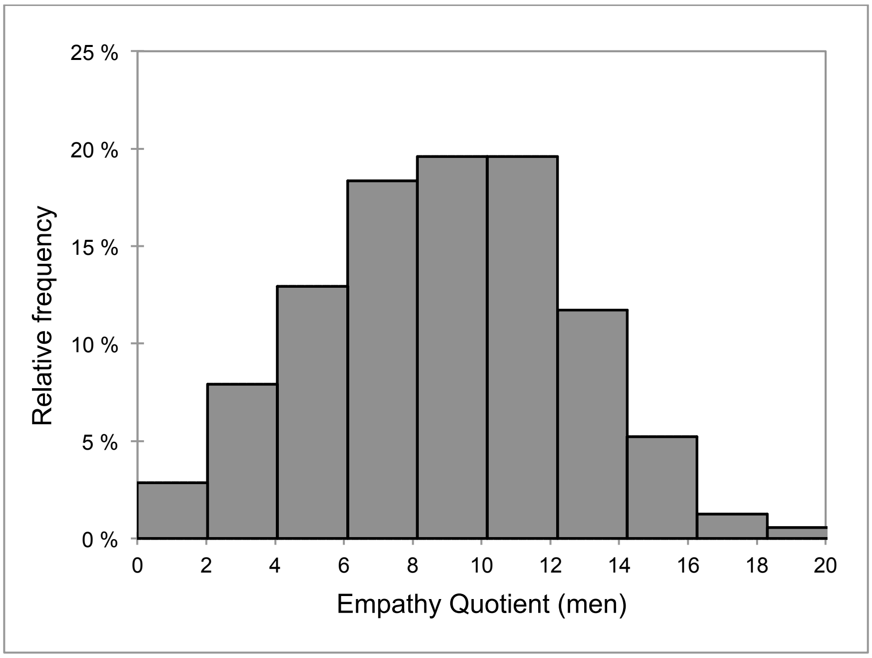

Figure 2. Distribution of the Empathy Quotient (range = 0.00, 19.33) for men.

Systemizing was assessed similarly, by using the short, 18-item version of the Systemizing Quotient (SQ) scale (Ling, Burton, Salt, & Muncer, 2009; for the original 60-item scale, see Baron-Cohen et al., 2003). The SQ measure focuses on technicity, topography, DIY and structure (e.g. "I can easily visualize how the motorways in my region link up".) The response scale was the same as in the EQ-Short, and the same procedure of approximating the final sum variable to account for missing data was utilized. The reliability (Cronbach's α) was .85. The distributions of the SQ variable can be seen in Figure 3 (women) and Figure 4 (men), and descriptive statistics in Table 1.

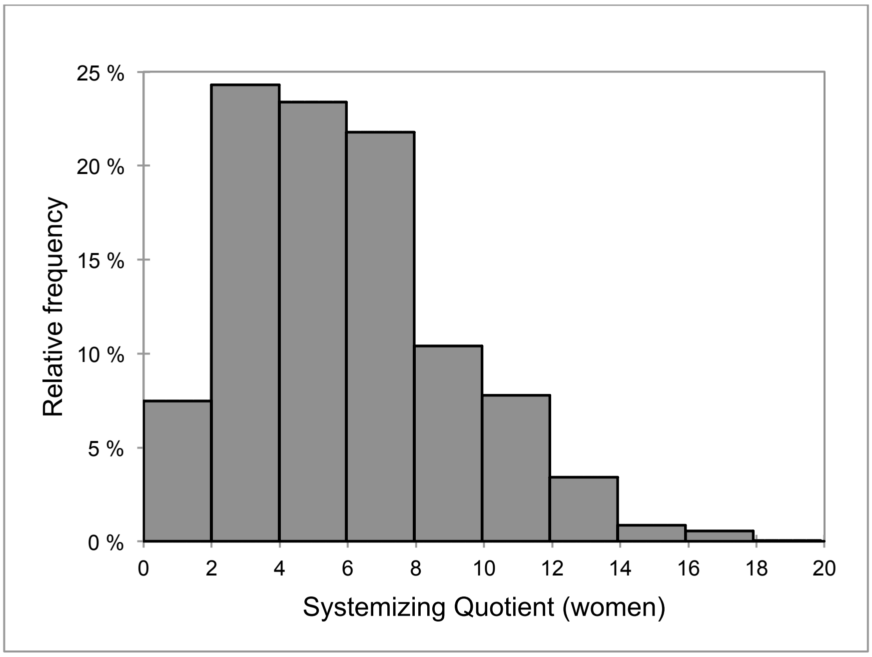

Figure 3. Distribution of the Systemizing Quotient (range = 0.00, 18.89) for women.

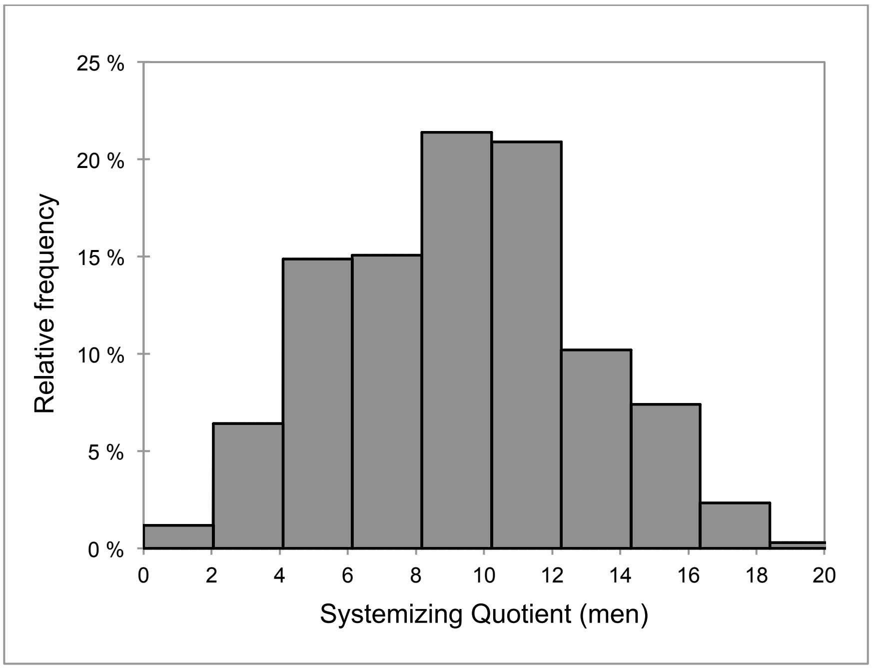

Figure 4. Distribution of the Systemizing Quotient (range = 0.00, 19.44) for men.

In order to operationalize the male brain type and the female brain type, the SQ and EQ scores were converted onto the same scale by dividing each score by the number of items in the scale and multiplying by ten. Following Wakabayashi et al. (2006), brain type scores were then calculated by subtracting the EQ scores from the SQ scores. Therefore, a high score above 0 indicates a systemizing, "male brain type", and a low score below 0 an empathizing, "female brain type", while a score close to 0 indicates a balanced brain type. Descriptive statistics for the resulting brain type variable can be found in Table 1. Upon visual examination, the variable was found to be normally distributed. In the case of female participants, the location of the distribution was shifted toward the lower, empathizing end of the scale. The distributions of the brain type variable are presented in Figure 5 (women) and Figure 6 (men).

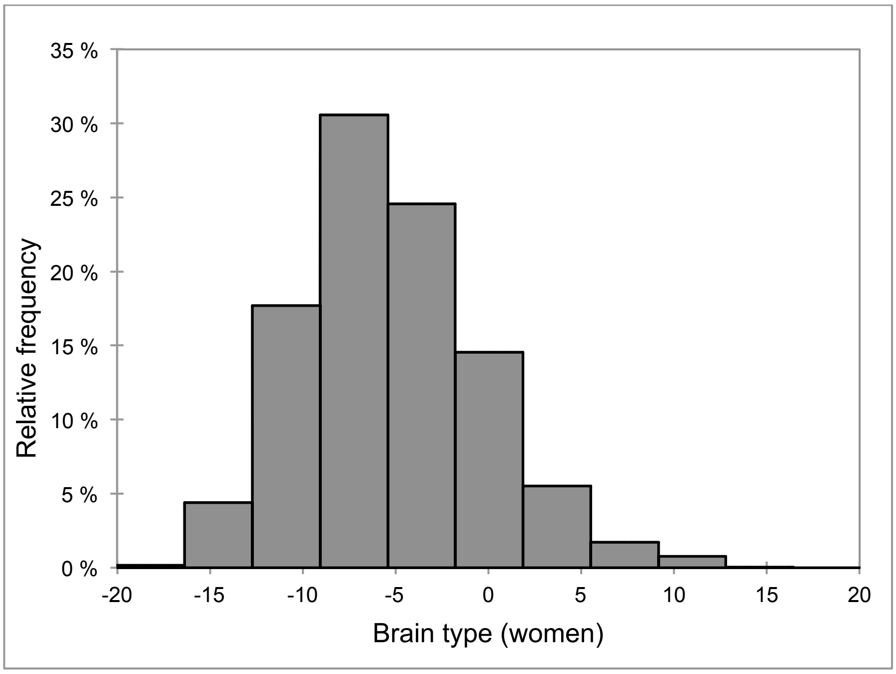

Figure 5. Distribution of brain type (range = −17.00, 15.44) for women. Low values indicate female brain type and high values indicate male brain type.

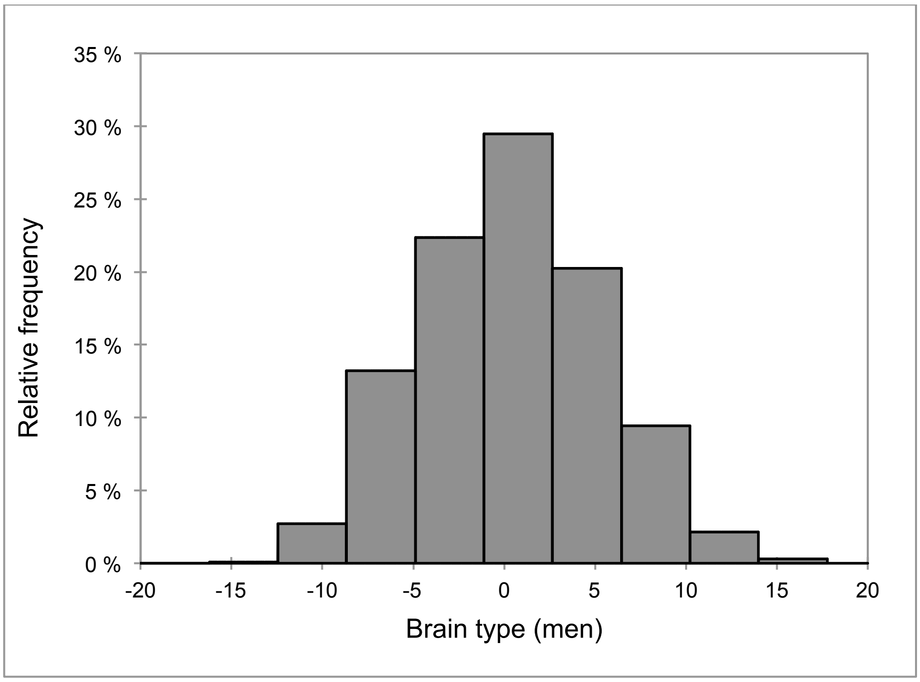

Figure 6. Distribution of brain type (range = −13.45, 16.78) for men. Low values indicate female brain type and high values indicate male brain type.

Table 1

Descriptive statistics of Systemizing Quotient (SQ), Empathizing Quotient (EQ), and brain type (SQ-EQ) for women, men, and all participants

Group	Variable	*M*	*SD*	Min	Max	*N*
Women	SQ	5.92	3.18	0.00	18.89	1955
	EQ	11.18	3.53	0.00	19.33	1993
	Brain type	−5.26	4.86	−17.00	15.44	1955
Men	SQ	9.37	3.60	0.00	19.44	1029
	EQ	9.08	3.62	0.00	19.33	1051
	Brain type	0.31	5.04	−13.45	16.78	1028
All	SQ	7.11	3.72	0.00	19.44	2984
	EQ	10.46	3.70	0.00	19.33	3044
	Brain type	−3.34	5.59	−17.00	16.78	2983

This brain type measure was used to identify four groups of participants: male brain type women, female brain type women, male brain type men, and female brain type men. The groups were identified as in Baron-Cohen (2002), by using one standard deviation from the 0-point of the scale as the cut-off point for male and female brain types: individuals scoring at least one standard deviation above the 0-point represented the male brain type, and individuals scoring at least one standard deviation below the 0-point represented the female brain type. Therefore, the participants representing the “balanced brain type” were excluded from the analyses. An exception to the standard deviation grouping principle was made in the case of male brain type women: as the group of women scoring above one standard deviation from the 0-point proved too small (47 people), the 90th percentile point, located 0.80 standard deviations above the mean, was substituted as the cut-off point. The final group sizes were as follows: 201 male brain type women, 994 female brain type women, 132 female brain type men, and 152 male brain type men. In all analyses, each opposite brain type group was compared to the typical brain type group of the same sex.

2.2.2 Correlates

Occupational or educational field was investigated using two different measures. The first one distinguished between systemizing-oriented and empathizing-oriented fields. Participants were asked to select their field from a list of 22 options. Adapting a similar approach to that of Svedholm-Häkkinen and Lindeman (2016), eight of the fields were chosen to represent empathizing-oriented and systemizing-oriented occupations. Of these, five were empathizing-oriented fields: the health care industry, education, psychology, social psychology, and other work in social services or human resources. The three systemizing-oriented fields were physics, chemistry or astronomy, mathematics, and IT and technology. These were combined into a variable indicating occupational focus on either systemizing or empathizing. The items left out of this measure included biology and earth sciences, beauty, culture and the humanities, law, sports, medicine, forestry, hospitality, art and design, architecture, finance and business, religion or theology, the social sector, and “other or none”.

The second measure used was a rating of vocational focus developed by Svedholm-Häkkinen and Lindeman (2016) based on Su et al. (2009). The participants rated the importance of the following focus areas in their work or study: 1) data and facts, 2) ideas, 3) people (encountering people in e.g. helping, educating, informing, services, entertainment, sales, or motivating), or 4) things (e.g. machinery, materials, or tools as the focus of the work, not only as instruments). The importance of each of the four focus areas was rated on a 4-point scale (1 = *no focus*, 4 = *high focus*). Each area was rated separately, but participants were asked to give the highest rating to only one of the focus areas. While the foci on people and things were considered to most clearly reflect empathizing and systemizing, respectively, the foci on data and ideas were also included in the basic analyses for explorative purposes. The first occupational measure, described above, was used for *t*-tests, and this second measure of occupational focus was used for conducting chi-squared tests in order to optimally utilize the data and to allow for potential converging evidence to emerge. The second measure was also chosen for a logistic regression analysis due to the larger sample size it allowed.

Parents' occupational focus was investigated using the vocational focus measure based on data, ideas, people, and things described above. However, each focus area was not rated independently; instead, participants chose one area which they assessed to be the primary focus of their mother's work, and one area to describe their father's work. Only the people and things foci were used in analyses in order to establish a clear distinction between a focus on empathizing or systemizing.

School grades in mathematics and physics (scale: 4–10) were requested as part of participants' background information. They were used as a measure of ability in systemizing-related subjects.

Hobbies were investigated with participants' ratings of whether they were interested in 24 hobbies. The list of hobbies was based on lists used by Rubinstein and Lansisky (2013) and Official Statistics of Finland, and the hobbies selected for the list evenly represented hobbies preferred more by men, hobbies preferred more by women, and gender-neutral hobbies. The feminine hobbies were: clothes or fashion, watching romantic movies, cooking, interior decoration, reading romantic literature, going to concerts, going to the theater, and group fitness classes. The masculine hobbies were: fishing, cars, watching sports programs, watching action movies, reading action literature, computers, playing computer games, and team sports. The measure also included gender-neutral hobbies, which were not included in the analyses: watching TV, watching other movies, reading other literature, other music hobbies, other games, other exercise, photography, and museums and exhibits. Participants were given one point for each hobby they checked on the list, and a feminine and a masculine hobby score were formed as the sum of the points in each category. These sums were divided by the number of all hobbies checked in order to form scores expressing relative interests in feminine and masculine hobbies.

Cognitive empathic ability was measured with the revised version of the Adult Reading the Mind in the Eyes Test (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). The original test consists of 36 photographs depicting the eye region of the faces of actors, and it is used to assess the extent to which an individual understands what the person in the picture is thinking or feeling. Thirteen of the photographs were used here. The items were selected to evenly represent easy, average, and difficult items, based on the normative data in Baron-Cohen et al. (2001). For each item, the participants were asked to choose the best descriptor of what the depicted person is feeling. Four emotion words were given as choices for each item, three of which were foil terms and one correct. As in the original instructions, the participants were asked to complete the test as quickly as possible. Due to the nature of the Eyes test, Cronbach's α is not usually calculated to estimate reliability (Fernández-Abascal, Cabello, Fernández-Berrocal, & Baron-Cohen, 2013). However, the original Eyes test has been shown to have good test-retest reliability and to differentiate between control subjects and individuals with autism spectrum disorder, schizophrenia, or social anxiety, and so can be considered a valid measure (for a review, see Fernández-Abascal et al., 2013).

Social connectedness was measured using the six-item ($\alpha = .82$) Friendship Scale (Hawthorne, 2006). The scale consists of statements relating to dimensions of isolation or connectedness (e.g. "I have someone to share my feelings with," "I feel isolated from people"), and the respondent rates how well each item describes him or her on a 4-point scale (1 = *almost always*, 4 = *not at all*). The average score is then calculated.

Sex role identity in terms of masculinity and femininity was measured with the 20-item Bem Sex Role Inventory (SRI; Bem, 1981, as cited in Svedholm-Häkkinen & Lindeman, 2016). The subscales used include traditionally masculine ($\alpha = .84$) and feminine ($\alpha = .89$) characteristics. Participants rated how well each of the characteristics described them using a 7-point scale (1 = *hardly ever*, 7 = *always or almost always*). The masculine scale includes characteristics such as "independent," "confident," and "willing to take risks." Examples of the feminine subscale include "understanding," "considerate of others' feelings," and "heartfelt." Scoring consisted of determining the average rating in each subscale.

3. Results

As a brief overview of the results, the hypothesized differences between the male and female brain types were found in school grades in mathematics and physics, occupational or educational fields, parents' occupational focus (for women), hobbies, cognitive empathic ability (for women), social connectedness, and female sex role identity. The differences in parents' occupational focus and cognitive empathic ability for men approached statistical significance, and no effects were present in terms of masculine sex role identity. Finally, predictive ability in determining brain type was investigated through logistic regression modeling using the variables in which between-group differences were found. The results are described below.

3.1 Occupational or educational field

When analyzing the relationship between occupational or educational field and brain type, differences between male brain type and female brain type women were found. On the measure indicating occupational field in empathizing or systemizing, male brain type women worked or studied in systemizing-related fields and female brain type women in empathizing-related fields more often that would be expected (χ^2 (1) = 137.416, p < .001). These results are shown in Table 2, which demonstrates that the association between brain type and occupational/educational field is quite strong, with the clear majority in each brain type occupied in the hypothesized fields. Differences between male and female brain type women were also found on the measures of occupational focus on data, ideas, people or things. In the focus on people, male brain type women rated their focus lower (*M* =

2.55) than did female brain type women (*M* = 3.21), $t(1177) = 8.977$, $p < .001$, with the difference between the groups representing 0.79 standard deviations. In things, male brain type women had a higher focus rating (*M* = 2.01) than did female brain type women (*M* = 1.68), $t(1177) = -5.571$, $p < .001$), which translates into a between-group difference of 0.52 standard deviations. Also in the case of data, male brain type women rated their focus 0.45 standard deviations higher (*M* = 2.82) than did female brain type women (*M* = 2.39), $t(1180) = -5.856$, $p < .001$. In the focus on ideas, no statistically significant association was found. The results are summarized in Table 3. The results of these analyses support hypothesis 1 (compared to female brain type women, male brain type women more often work in occupations with a focus on systemizing or things).

The hypothesized associations held also for men. On the measure indicating occupational focus on empathizing or systemizing, female brain type men worked or studied in empathizing-related fields and male brain type men in systemizing-related fields more often than would be expected (χ^2 (1) = 34.181, $p < .001$). Table 2 contains these results, showing that the effect is quite strong for male brain type men and somewhat less prominent for female brain type men. Differences were found also on the measure of occupational focus on data, ideas, people or things. In the case of focus on people, female brain type men rated their focus 0.79 standard deviations higher (*M* = 3.21) than did male brain type men (*M* = 2.45), $t(278) = -6.773$, $p <.001$. In focus on things, female brain type men rated their focus lower (*M* = 2.13) than did male brain type men (*M* = 2.68), $t(281) = 4.334$, $p < .001$, which translates into an effect size of 0.52 standard deviations. In focus on data, female brain type men rated their focus lower (*M* = 2.58) than did male brain type men (*M* = 3.13), with a between-group difference of 0.59 standard deviations. In focus on ideas, there was no statistically significant difference. These results can be seen in Table 3. Altogether, the analyses lend support for hypothesis 8 (compared to male brain type men, female brain type men more often work in occupations with a focus on empathizing or people).

Table 2

Comparison of occupational or educational field between the opposite and typical brain types

	Occupational/ educational field	Male brain type	Female brain type	*n*
Women	Empathizing	11 (22.9%)	316 (91.1%)	327
	Systemizing	37 (77.1%)	31 (8.9%)	68
	N	48 (100%)	347 (100%)	395
Men	Empathizing	6 (7.9%)	22 (57.9%)	28
	Systemizing	70 (92.1%)	16 (42.1%)	86
	N	76 (100%)	38 (100%)	114

Table 3

Comparison of occupational focus between the opposite and typical brain types

		M (*SD*)				
	Occupational focus	Male brain type	Female brain type	*t*	*df*	*p*
Women	Data	2.82 (1.01)	2.39 (0.92)	−5.856	1180	<.001
	Ideas	3.29 (0.89)	3.30 (0.75)	0.188	1180	.851
	People	2.55 (0.98)	3.21 (0.93)	8.977	1177	<.001
	Things	2.01 (1.01)	1.68 (0.83)	−5.571	1177	<.001
Men	Data	3.13 (0.91)	2.58 (0.87)	5.152	277	<.001
	Ideas	3.23 (0.82)	3.01 (0.91)	1.681	277	.094
	People	2.49 (0.87)	3.21 (0.90)	−6.773	278	<.001
	Things	2.68 (1.11)	2.13 (1.03)	4.334	281	<.001

3.2 Parents' occupational focus

Next, participants' parents' occupational focus areas were investigated. In women, the male and female brain type groups differed in terms of their parents' occupations. The fathers of male brain type women worked more often than expected in occupations with a focus on things rather than people, whereas the fathers of female brain type women were more often in people-focused fields (χ^2 (1) = 7.660, p = .006). The mothers of male brain type women were also more likely than expected to work in fields with a focus on things, whereas the mothers of female brain type women were more likely to work with people ($\chi^2(1)$ = 7.283, p = .007). The results confirm hypothesis 2 (compared to female brain type women, male brain type women more often have parents who work in technical fields and less often parents whose work focuses on people), and are listed in Table 4. As can be seen in the table, the associations between focus on people and the female brain type, and focus on things and the male brain type, were more prominent for participants' mothers than fathers.

Table 4

Female participants' parents' occupational focus (things vs. people)

	Occupational focus	Male brain type	Female brain type	*n*
Fathers	People	36 (31.3%)	283 (45.2%)	319
	Things	79 (68.7%)	343 (54.8%)	422
	N	115 (100%)	626 (100%)	741
Mothers	People	116 (82.3%)	613 (90.1%)	729
	Things	25 (27.2%)	67 (9.9%)	92
	N	141 (100%)	680 (100%)	821

These connections were not statistically significant in men. While associations between the female brain type and parents' occupational focus on people as well as the male brain type and parents' focus on things were present, they merely approached statistical significance in the case of fathers (χ^2 (1) = 3.304, p = .069) and were not statistically significant in the case of mothers. Therefore, hypothesis 9 (compared to male brain type men, female brain type men more often have parents whose work focuses on people and less often parents who work in technical fields) is not supported by the results.

3.3 School grades in mathematics and physics

In women, differences between the brain types were found in terms of school performance in systemizing-focused school subjects. Male brain type women had received higher physics grades (M = 8.27) in school than had female brain type women (M = 7.78), t(1183) = −4.900, p < .001. This difference represented 0.38 standard deviations. In mathematics as well, male brain type women's grades had been higher (M = 8.44) than female brain type women's (M = 7.90), t(1185) = −5.163, p < .001, meaning an effect size of 0.42 standard deviations. Therefore, hypothesis 3 (compared to female brain type women, male brain type women have received higher grades in mathematics and physics) was supported by the data.

The hypothesized associations were present also for men. In physics, female brain type men had received lower school grades (M = 7.40) than had male brain type men (M = 8.29), t(280) = 5.959, p < .001. Similarly, in mathematics, female brain type men reported lower grades (M = 7.41) than did male brain type men (M = 8.36), t(280) = 6.137, p < .001. The effect sizes were 0.65 standard deviations for the between-group difference in physics and 0.68 standard deviations in mathematics. These results support hypothesis 10 (compared to male brain type men, female brain type men have received lower grades in mathematics and physics).

3.4 Hobbies

On the measures of feminine and masculine hobbies, the hypothesized between-group differences were present. Male brain type women had fewer feminine hobbies (*M* = .26) than did female brain type women (*M* = .42), $t(1161) = 10.545$, $p < .001$, with a difference of 0.85 standard deviations. In masculine hobbies, there was a between-group difference of 0.78 standard deviations: male brain type women had more masculine hobbies (*M* = .20) than did female brain type women (*M* = .09), $t(1161) = 11.080$, $p < .001$, confirming hypothesis 4 (compared to female brain type women, male brain type women have more hobbies that are typically considered to be masculine and/or fewer hobbies considered to be feminine).

In the case of men, persons representing the female brain type had more feminine hobbies (*M* = .20), than did male brain type men (*M* = .13), $t(278) = -2.881$, $p < .001$, with the difference equaling 0.47 standard deviations. Female brain type men also had fewer masculine hobbies (*M* = .31) than did male brain type men (*M* = .40), $t(278) = 3.841$, $p < .001$, representing an effect size of 0.43 standard deviations. Hypothesis 11 (compared to male brain type men, female brain type men have more hobbies that are typically considered to be feminine and/or fewer hobbies considered to be masculine) was therefore confirmed.

3.5 Cognitive empathic ability

When analyzing the differences between male and female brain type women, the male brain type women received lower scores (*M* = 8.67) on the Eyes test than did female brain type women (*M* = 9.41), $t(1181) = 5.407$, $p < .001$, with the difference translating into 0.42 standard deviations. This supports hypothesis 5 (compared to female brain type women, male brain type women have lower cognitive empathic ability).

In the case of male and female brain type men, the corresponding hypothesized difference did not receive clear support. However, the results closely approached statistical significance: female brain type men received slightly higher scores (*M* = 8.92), more specifically 0.25 standard deviations higher, than did male brain type men (*M* = 8.45),

$t(281) = -1.932$, $p = .054$. The result suggests a possible connection, and so neither confirms nor strongly refutes hypothesis 12 (compared to male brain type men, female brain type men have higher cognitive empathic ability).

3.6 Social connectedness

When investigating female participants on their Friendship Scale scores, male brain type women were found to have a lower social connectedness score ($M = 2.51$) than did female brain type women ($M = 3.21$), $t(1158) = 16.714$, $p < .001$. This between-group difference represents 1.16 standard deviations, and supports hypothesis 6 (compared to female brain type women, male brain type women are less socially connected).

In support of hypothesis 13 (compared to male brain type men, female brain type men are more socially connected), a difference of 1.08 standard deviations between the brain type groups was found in men: on average, female brain type men scored higher ($M = 3.12$) on the Friendship Scale than did male brain type men ($M = 2.46$), $t(278) = 11.001$, $p < .001$.

3.7 Sex role identity

Brain type was associated with feminine sex role identity in women. Male brain type women scored 1.48 standard deviations lower on feminine sex role identity ($M = 4.05$) than did female brain type women ($M = 5.42$), $t(1192) = 22.673$, $p < .001$, but in masculine sex role identity, there was no statistically significant difference between the male brain type ($M = 4.53$) and female brain type ($M = 4.51$) women, $t(1193) = -0.261$, $p = .794$. In terms of feminine sex role identity, these results support hypothesis 7 (compared to female brain type women, male brain type women have a gender role identity higher in masculinity and/or lower in femininity).

Feminine sex role identity differed between the brain type groups also in men. Female brain type men received higher scores on female sex role identity ($M = 5.41$) than did male brain type men ($M = 3.77$), $t(282) = 15.671$, $p < .001$, the difference between the group averages representing 1.64 standard deviations. No difference was found in terms of masculine gender identity between female ($M = 4.61$) and male ($M = 4.63$) brain type men, $t(282) = 0.150$, $p = .881$. Therefore, similarly to the results for women, these analyses support hypothesis 14 on feminine gender role identity (compared to male brain type men, female brain type men have a gender role identity higher in femininity and/or lower in masculinity).

3.8 Logistic regression

A logistic regression analysis was conducted for both women and men in order to investigate the relative importance of the variables presented above in discriminating between the male and female brain types in each gender. Because of multicollinearity some choices and combinations between variables were necessary. Only the variables in which between-group differences were present were included in the analyses. The variables indicating occupational focus on people and things were used as indices of occupational field. School grades in mathematics and physics were combined into one variable indicating the average grade in these subjects, as they were highly correlated ($r = .665$). Masculine and feminine hobbies were also combined into one variable by subtracting the proportion of male hobbies from the proportion of female hobbies, thereby forming a variable in which a higher score indicates a larger proportion of female hobbies, and a lower score a larger proportion of male hobbies.

In the analysis conducted for female participants, a test of the full model against a constant-only model showed the model to be statistically significant, indicating that the predictors reliably distinguished between male brain type and female brain type women ($\chi^2 = 259.61$, $p < .001$, $df = 9$). Nagelkerke's R^2 of .672 indicated a good, although not strong, relationship between prediction and grouping. The overall prediction success was 92% (68.5% for the male brain type and 97.3% for the female brain type). The resulting model is described in detail in Table 5. As can be seen in the table, the statistically significant variables in terms of predicting the male brain type (vs. the female brain type) were mother's occupational focus on things (compared to people), the participant's own occupational focus on things, a higher average grade in mathematics and physics, a higher proportion of masculine than feminine hobbies, lower social connectedness, and lower feminine gender identity. Among these variables, the highest odds ratios were associated with occupational focus on things and the average grade in physics and mathematics, while the other odds ratios remained relatively modest.

Table 5

Logistic regression analysis for female participants, male (vs. female) brain type

Source	*B*	*SE B*	Wald χ^2	*p*	OR	95% CI
Father's occupational focus	−0.52	0.42	1.56	.212	0.60	[0.26, 1.34]
Mother's occupational focus	−1.56	0.50	9.71	.002	0.21	[0.08, 0.56]
Focus on people	−0.33	0.20	2.56	.108	0.72	[0.48, 1.08]
Focus on things	0.60	0.20	8.86	.003	1.82	[1.23, 2.69]
Mathematics/physics grade	0.32	0.16	4.11	.043	1.38	[1.01, 1.89]
Hobbies	−3.02	0.68	19.83	<.001	0.05	[0.01, 0.19]
Cognitive empathic ability	−0.12	0.10	1.43	.232	0.88	[0.72, 1.08]
Social connectedness	−1.23	0.31	15.30	<.001	0.29	[0.16, 0.54]
Feminine gender identity	−1.70	0.24	48.62	<.001	0.18	[0.11, 0.29]

Note. Lower, negative values in father's and mother's occupational focus indicate a focus on people compared to things. Lower/negative values in hobbies indicate more masculine hobbies compared to feminine hobbies. OR = odds ratio; CI = confidence interval.

The analysis for men included fewer variables as there were fewer statistically significant associations between the brain types and the correlates investigated. Also for men, a test of the full logistic regression model indicated it distinguished between the brain types on a statistically significant level ($\chi^2 = 237.47$, $p < .001$, $df = 6$). Based on a Nagelkerke's R^2 value of .774, the model was able to explain the variation in the data relatively well. Overall, the model was able to predict brain type in 90% of the cases (91.8% for female brain type men and 88.2% for male brain type men). The variables in the model are described in Table 6. As shown in the table, the variables that reached statistical significance in predicting the female (vs. male) brain type in men were the average grade in mathematics and physics, social connectedness, and feminine sex role identity. In addition, low occupational focus on things and feminine hobbies approached statistical significance. Social connectedness, feminine sex role identity, as well as feminine hobbies had relatively high odds ratios, while those associated with the other variables were relatively low.

Table 6
Logistic regression analysis for male participants, female (vs. male) brain type

Source	*B*	*SE B*	Wald χ^2	*p*	OR	95% CI
Focus on people	0.13	0.25	0.28	.595	1.14	[0.70, 1.85]
Focus on things	−0.38	0.21	3.31	.069	0.69	[0.46, 1.03]
Mathematics/physics grade	−0.75	0.19	15.24	<.001	0.47	[0.32, 0.69]
Hobbies	1.31	0.79	3.20	.074	4.11	[0.87, 19.34]
Social connectedness	2.37	0.43	30.32	<.001	10.65	[4.59, 24.71]
Feminine gender identity	1.85	0.30	37.14	<.001	6.34	[3.50, 11.49]

Note. Higher, positive values in hobbies indicate more feminine hobbies compared to masculine hobbies. OR = odds ratio; CI = confidence interval.

4. Discussion

4.1 Opposite brain types' associations with qualities of the opposite sex

Most of the hypotheses proposed received support in this study. More specifically, the hypothesized associations held between brain type and occupational or educational fields (hypotheses 1 and 8), parents' occupational focus in the case of women (2), school grades in mathematics and physics (3 and 10), hobbies (4 and 11), cognitive empathic ability in the case of women (5), social connectedness (6 and 13), and sex role identity in terms of female sex role identity (7 and 14). In terms of masculine sex role identity, hypotheses 7 and 14 did not receive support. For men, the associations between brain type and parents' occupational focus (9), and cognitive empathic ability (12) were neither clearly confirmed nor refuted. Overall, the results of the current study indicate that a trend exists in which the opposite brain type is linked to the interests and skills more often associated with the so-called opposite sex; female brain type men differ from male brain type men in terms of skills, careers, and hobbies that are typically considered to be feminine, and male brain type women differ from female brain type women by exhibiting more skills and interests typically considered to be masculine.

In occupational or educational areas, female brain type men and women had an increased likelihood of working in fields or studying subjects that relate to people or empathizing and are traditionally considered to be feminine. Similarly, male brain type men and women were both likely to be occupied in areas that require systemizing, which are typically seen as masculine. In other words, compared to individuals exhibiting the typical brain types, female brain type men were more similar to women, and male brain type women to men. While systemizing has been associated with success and interest in technology and the STEM fields (Nettle, 2007; Su et al., 2009; Byrd-Craven et al., 2015; Ruzich et al., 2015), and empathizing with skills and interests related to people (Baron-Cohen, 2003; Su et al., 2009), the link between brain type and occupational area in individuals exhibiting the opposite brain types has not been established or studied before. The findings here suggest that the connections between men and systemizing and women and empathizing are not enough to constitute a natural explanation for the gendered structures in working life, as Baron-Cohen, 2003 suggests: the opposite brain type groups show that relying on such an explanation ignores parts of the population, and additionally, the systemizing-empathizing theory does not account for the many social factors influencing career choices (Eagly & Wood, 1999; Cheryan et al., 2016). In future research, studying brain type independently of biological sex could facilitate building a more accurate understanding of the gender structures in working life, such as the underrepresentation of women in STEM occupations or that of men in people-focused work. In addition to the results regarding individual career choices, the association found between women's brain type and their parents' occupational foci adds to prior research connecting autistic traits with male family members working in engineering and related fields (Baron-Cohen, Wheelwright et al., 1997), as it suggests a possible familial influence between cognitive styles and career choices within the normal population.

Cognitive empathic ability and social connectedness, which are typically associated with femininity and the empathizing cognitive style (Baron-Cohen, 2003; Baron-Cohen & Wheelwright, 2004), were also associated with the female brain type rather than only with biological sex. The female brain type was connected to a higher level of cognitive empathic ability and social connectedness in both women and men, while the male brain type in both women and men was connected to a lower level of these qualities. While previous research has found empathizing to be an important component of people-related skills and women to have a higher level of empathizing when compared to men (Baron-Cohen, 2002; Baron-Cohen, 2003; Nettle, 2007), this study found an association between a higher than average level of empathizing and people-related skills in men as well. This finding suggests that people-related skills and abilities are connected to the extent of a person's drive to empathize instead of simply biological sex, even though previous research typically approaches this subject as a matter of sex differences (McClure, 2000; Baron-Cohen & Wheelwright, 2004; Baron-Cohen et al., 2005; Nettle, 2007). Although other factors may also influence different social skills, these results give reason to ask whether studying differences between men and women without considering differences in the cognitive styles of systemizing and empathizing represents a simplified perspective on the matter.

In terms of hobbies, individuals exhibiting the opposite brain types showed similarity to their opposite sex when compared to those with the typical brain types: male brain type women had more masculine hobbies and fewer feminine hobbies than did female brain type women, and female brain type men had more feminine and fewer masculine hobbies compared to male brain type men. These results expand on prior knowledge: whereas previous research has found sex differences in hobbies (Twenge, 1999; Su et al., 2009), the results presented here suggest that the male and female brain types play a role in these differing interests, and the opposite brain types emerge as clear exceptions to the general tendencies found in previous studies. Since empathizing and systemizing represent different ways of interpreting phenomena as well as different skills and abilities, it appears likely that these drives are connected to the kinds of hobbies individuals find interesting. For example, many masculine hobbies have a systematic quality that can make them interesting to high systemizers, including both male brain type men and male brain type women. All gender differences in hobbies are unlikely to be explained by only brain type (see Nettle, 2007), although Baron-Cohen (2003) sees the difference in drives to empathize and systemize as an all-encompassing explanation for sex differences. However, this explanation does not include the opposite brain types. It is possible that a more accurate understanding of the division of stereotypically masculine and feminine free-time interests could be reached by including differences in empathizing and systemizing in future study designs as well.

Feminine sex role identity was strongly associated with the female brain type in both men and women. While associations involving the male brain type were not found in this study, previous research on gender identity has shown a connection between masculine gender identity and a high level of performance in some problem-solving skills (Milton, 1957) and in spatial ability (Reilly & Neumann, 2013), which could indicate a connection to the drive to systemize. In this case, future research, using more sophisticated measures of sex role identity, may be able to connect both the male and female brain type to sex role identities. The Bem Sex Role Inventory used here (Bem, 1981, as cited in Svedholm-Häkkinen & Lindeman, 2016) includes 20 self-assessment items, and so is a relatively short measure relying on subjective and potentially inaccurate answers. It is also possible that, for reasons that cannot be deciphered here, there is more variation in feminine sex role identity than in masculine sex role identity between the brain types. Whereas sex role identity research has found differences in skills relating to femininity and masculinity (Reilly & Neumann, 2013), studies on empathizing and systemizing have focused on differences in terms of biological sex: women have been found to empathize to a greater degree than men and men to systemize more than women (Baron-Cohen, 2002). In the present study, a novel combination of these areas was formed by looking at the connections between the opposite brain types and sex role identity. The found associations provide evidence that the issue of gender differences is a multifaceted one and warrants further investigation. Because the opposite brain type groups differ from their typical counterparts in terms of sex role identity, there may be larger structures of masculine and feminine qualities that intercorrelate but can be associated with either sex. It may be useful for future research concerning sex role identity to include the cognitive styles of empathizing and systemizing.

Looking at the results of this study as a whole, the qualities with the most predictive power in terms of cognitive style were performance in mathematics and physics, level of social connectedness, and feminine sex role identity. In addition, occupational focus on things or systems, hobbies, and mother's occupational focus on things or systems predicted male brain type in women. For men, feminine or masculine hobbies and occupational focus on things appeared to be potentially meaningful factors, although their role was not unequivocally determined. Feminine sex role identity stood out as a particularly interesting area for further research, as it had good predictive power for the cognitive styles of both men and women, and it was associated with particularly large differences between the male and female brain type groups in both sexes. Empathizing and systemizing may not be important only in terms of different interests and cognitive skills, but also in matters relating to gender identity.

On four occasions, hypotheses were not confirmed or received only partial support. Most of the unconfirmed associations involved men. It is possible that either brain type is more strongly associated with the correlates investigated in women than in men, or that men are less likely to express themselves in ways that reveal those associations when filling out surveys and tests. As many qualities associated with masculinity are typically assigned higher value than those associated with femininity (see e.g. Ely & Meyerson, 2000), there may be a discrepancy between feminine or masculine qualities and the desire to act or report on those interests, particularly among men who may feel a need to portray a certain level of masculine qualities. Therefore, the use of self-evaluation questionnaires may not have reached all existing associations. For example, in a self-evaluation assessment of sex role identity features, it is conceivable that there could be a higher threshold for men to describe themselves as more feminine than masculine than there is for women to choose masculine attributes instead of feminine ones. It may also be more socially acceptable for women to pursue interests that are seen as more masculine due to their higher social valuation. Therefore, social factors may affect women and men differently not only in terms of how likely they are to pursue education and careers in the areas they are interested in, but also in terms of how likely they are to report these interests. Future research can shed more light on the unresolved areas that stand out from the general trend of the results presented here.

Despite the lack of a few hypothesized connections, the general conclusion from the findings presented here is that the opposite brain types are associated with several qualities and skills more commonly associated with the so-called opposite sex. The kinds of gender differences studied here seem to form “gender-typed” groups of occupations, hobbies, skills, and sex role identity features that have different connections to the brain types, not simply to gender. Prior research connects different stereotypically feminine qualities to women and the female brain type, and different masculine qualities to men and the male brain type (Baron-Cohen, 2003; Baron-Cohen et al., 2005; Baron-Cohen, 2009; Eagly & Wood, 1999; Halpern et al., 2011). However, the research at hand adds to this knowledge the discovery that the male brain type is associated with qualities typically considered to be masculine in both women and men, and the female brain type, not only for women but also for men, is linked to qualities typically seen as feminine. While the female brain type may be more common in women and the male brain type in men (Baron-Cohen, 2003), future research should take into consideration that male brain type women and female brain type men also exist and are not represented in studies focusing on identifying gender-based effects.

What brings about these atypical gender-typed groups of attributes and differences in empathizing and systemizing may well be partly biological and partly social. It appears that there are common, biologically based predispositions for empathizing and systemizing that are present early in life (see Baron-Cohen, 2007; Connellan et al., 2000), but the existence of the opposite brain type groups indicates that there are more factors at play in determining brain type than biological sex. The female and male brain types may not be quite as comprehensive a blanket explanation for all gender-related phenomena as has been suggested (Baron-Cohen, 2003; Baron-Cohen et al., 2005), as Nettle (2007) has also argued. The empathizing-systemizing theory does not speak of the opposite brain types and how they fit into the pattern of observed sex differences. The potential causal connections between biology, socialization, and the brain types may be quite multifaceted. Systemizing and empathizing could also be a part of a larger structure of interests, skills, and other psychological features that are seen as masculine or feminine. However, the study design utilized here does not allow for causal inferences, and therefore finding the causal direction between brain type and the qualities associated with them remains a topic for future research.

4.2 Limitations of the present study

While the results show an overall connection between cognitive styles and the investigated qualities, some limitations must be considered. As noted above, causal inferences concerning the direction of the influences between different attributes and the brain types are not possible based on this research. In addition, the distribution of the brain types in the sample used did not in every regard follow the general distribution established by Baron-Cohen (2003): among men, brain type was quite evenly distributed instead of shifted toward the systemizing, male brain type, while for women, the empathizing, female brain type was far more common than the male brain type, to the point that the grouping principle had to be adjusted in order to gain a large enough group of systemizing women. The rather extensive set of tests that participants were asked to respond to most likely resulted in some missing data and potentially also in some carelessly chosen answers. While the exact implications for the results are not clear, it is plausible that a more focused data collection method and a more optimally distributed data set could have rendered the analyses more powerful. However, the number of measures available as well as the large sample size also enabled investigating a multitude of variables in connection to the opposite brain types, and thereby applying a novel and useful approach to the study of gender differences and the cognitive styles of empathizing and systemizing.

4.3 Conclusions and future prospects

As the approach based on the opposite brain types represent a new area of study, many questions remain unanswered. One direction for future research is exploring the extent to which an individual's brain type matches his or her chosen occupation and hobbies in a sample that is representative of a larger population, which the sample utilized in this study was not. These kinds of generalizable results could help discern the practical effects of empathizing and systemizing in terms of occupational choices on a population level. Information concerning how well people's interests and abilities generally match their occupations could facilitate the quantitative estimation of the effects of social influences versus systemizing and empathizing in career choice. While the underrepresentation of women in the STEM fields has been widely researched (see e.g. Official Statistics of Finland, 2009; National Science Foundation, National Center for Science and Engineering Statistics, 2015; Cheryan et al., 2016), the results of these studies often describe gender divisions between lines of work or focus on social causes and implications rather than investigate intrapersonal psychological factors. Following the model set here, in which both the typical and opposite brain types are considered, further research concerning occupational choices on the level of brain types may provide a deeper understanding of gendered phenomena in our society.

The pattern of results discovered here lends credence to the possibility that the female and male brain types are associated with a larger cognitive structure; perhaps they are parts of structures of correlating qualities, or perhaps they are the underlying cause of such combinations of attributes. While Baron-Cohen (2003) argues that average differences in empathizing and systemizing are the source of all sex differences, a more complex picture including the opposite brain types is beginning to emerge. So far, the male brain type has received the most research focus. This is understandable, as the empathizing-systemizing theory stems from autism research and primarily seeks to explain autism spectrum disorder as resulting from the extreme male brain type (Baron-Cohen, 1995; Baron-Cohen, 2002; Lawson et al., 2004; Baron-Cohen, 2007). However, it is also a theory on sex differences (Baron-Cohen, 2003), and in light of the results of this study, one that calls for additional research and focus not only on the typical brain types but also on the opposite brain types.

Perhaps the most societally important conclusion from this study is that male brain type women and female brain type men represent a previously unknown factor in terms of a variety of gendered phenomena. The existence of these opposite brain types suggests that research on sex differences may not be able to fully reach the underlying causes of such differences by inferring causal connections based on observed average sex differences. Due to the average differences between men and women in the drives to empathize and systemize, a superficial look into gendered phenomena may give the appearance of simple sex differences in a variety of areas, including occupations, hobbies, social skills, and gender identity. The results presented here suggest that considering both brain types in both sexes in research can help build a more complete understanding in gender-related areas of inquiry. As Lai et al. (2012) have also argued, it may be time to move on from simple sex-based divisions in research and toward investigating differences in cognitive styles.

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