Parental Human Capital Traits and Autism Spectrum Disorder in Children

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Abstract

We examine whether and to what extent parental characteristics are related to autism spectrum disorder (ASD) diagnoses in children. A key insight we use in this paper is that parents' underlying traits are reflected in their choices of occupation and educational field, opening new avenues to understand intergenerational transmission of developmental disorders. To this end, we combine data from multiple administrative datasets from Danish registers and use saturated regression models that include information on parental occupations, education, family relationships and ASD diagnoses of children born between 1995 and 2010. Our project makes two substantive contributions. We add to existing evidence on the causal relationship between characteristics of parents and ASD prevalence in children, and we provide the first large-scale empirical assessment of medical theories linking assortative mating to ASD prevalence. We follow Baron Cohen et al. (1997) by characterizing educational and occupational choices as reflecting a "systemizing" trait. We show that systemizing of fathers, but not mothers, is related to ASD diagnosis rates, even conditional on parental age at birth, education level, income, geographic location, and other controls. We also find similar results when we examine the link between systemizing of paternal and maternal grandfathers and ASD diagnoses of grandchildren. Given

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that this relationship appears to operate exclusively through the paternal line, we also find no evidence that assortative mating on the basis of systemizing is linked to ASD prevalence.

Introduction

The U.S. Centers for Disease Control (CDC) currently estimates that for every 1000 8-year-olds residing in the U.S., 14.6 of them (one out of 68) meet the criteria for a diagnosis of Autism Spectrum Disorders (ASD). The prevalence has grown markedly over time; for example, in the same report, the CDC notes that the prevalence of ASD in 8-year-olds in 2000 was estimated to be 6.7 per 1000 (Christensen et al., 2012). Similarly high rates of ASD exist in Denmark (Hansen et al, 2015), and Parner et al. (2008) show a similar rise over time in ASD diagnoses. Researchers have linked autism diagnoses to a variety of genetic, environmental, economic, and social factors. Monozygotic twins are much more likely to both have ASD relative to dizygotic twins (Nordenbaek et al, 2014). Parents' age at birth appears to play a role in ASD incidence (e.g. King et al., 2009), and parents with higher socioeconomic status are more likely to have children diagnosed with ASD (e.g. Daniels and Mitchell, 2014). It is clear that at least part of the increase in diagnosis rates reflects increased diagnosis net of underlying incidence due to changing diagnostic criteria, improved detection and awareness (e.g. King and Bearman, 2009), and social networking leading to better information exchange (e.g. Fountain, King and Bearman, 2011). Even so, much is still unknown about understanding ASD rates, both within and across birth cohorts.

In this paper, we examine whether and to what extent specific parental traits are related to ASD diagnoses in children. One important complication is that it is very difficult to observe personality and behavioral traits in data with samples large enough to identify the impacts on relatively rare conditions like ASD. To address this, we posit that certain personality traits can be reflected in occupational and educational choices, such as fields of study while in upper secondary and postsecondary schooling. We utilize registry data from Denmark, which provides us with a large population to identify the roles of these traits. We build our empirical framework upon on a theory from the psychology literature that suggests that a heritable characteristic known as "systemizing" (Baron-Cohen, 2006) may be a key factor in ASD incidence.

According to Baron-Cohen, a person who is a systemizer thrives in situations in which there are clear rules and laws (known as "lawful" situations), whereas situations that involve uncertainty and chaos ("unlawful" situations) are more difficult to handle. Baron-Cohen (2006) provides an example in which a mathematical formula is 100% lawful – if you enter the same inputs, the formula will always provide the same output – while social situations are relatively

unlawful – the same inputs may lead to many different outputs. An individual with extremely systemizing traits has little ability to cope under unlawful situations, a key characteristic of ASD (Baron-Cohen, 2006). As a result, systemizing leads individuals to be more likely to choose certain educational and occupational paths. Baron-Cohen argues that systemizing may also be heritable, leading to having biological children who are themselves systemizers. If systematizing occurs on a spectrum, children can exhibit more or less systemizing behavior than their parents. Moreover, assortative mating of systemizers may make it more likely that a child will exhibit an extreme form of systemizing, which, according to the theory, manifests itself as ASD.

We provide a new way to test these theories by combining data from multiple administrative datasets from Danish registers – which include information on children's ASD diagnoses for those born between 1995 and 2010, parental occupations, parental education, and family relationships – to estimate the link between systemizing of fathers, systemizing of mothers, assortative mating of systemizers, and ASD diagnoses in children. To our knowledge, this is the first large-scale study to formally examine the link between parental characteristics associated with systemizing and ASD diagnoses in children. Further, this study shows how administrative data on economic choices can be used to improve our understanding of how the intergenerational transmission of traits contributes to the incidence of developmental disorders.

In order to operationalize the notion of systematizing, we rely on the theory that individuals with systemizing personalities are typically attracted to educational fields and occupations that involve orderly systems, such as engineering, information technology, computer science, and natural sciences. We categorize education and occupation outcomes of parents as proxies for systemizing traits. We do this in two ways. First, we classify parents' fields of study for their highest degree (including upper secondary school track, vocational training, or college major) into a binary variable indicating whether the field is indicative of systemizing. We then examine the impacts of having a systemizing mother and/or father on ASD incidence.

Our approach for categorizing occupations of parents is somewhat different (as we explain in more detail below), as it relies on concording data from the Occupational Information Network (O*NET) survey of United States occupations. These data provide ratings of the importance of a variety of knowledge, skills, and abilities (KSAs) to different occupations in the U.S. We match these data to Danish occupations and form an index of systemizing across Danish

occupations based on which KSA traits are indicative of systemizers, weighted by how important those KSAs are for a particular occupation.

In both strategies, we use saturated linear probability models to estimate the probability that a child is diagnosed with ASD as a function of the systemizing characteristics of parents and a host of detailed controls. In particular, we condition on the parents' level of education, the child's detailed location of birth, parental age and marital status, and income. An important benefit of using the Danish registry data is that we have detailed information on the child's background and a context where relatively flat income distributions, universal healthcare, and the availability of disability benefits limits socio-economic disparities in access to diagnoses. As a result, to the extent that our use of occupation and education fields provide sufficient statistics for systemizing, we argue that our estimates capture a causal channel through which parental systemizing traits influence ASD incidence.

We examine the ASD-systemizing link separately for occupation- and education-based measures of systemizing. The results are consistent across both dimensions: systemizing of fathers raises the probability of ASD in a child conditional on the other controls, whereas systemizing of mothers has no independent impact. For example, we find that having a father in a systemizing educational field raises the probability of being diagnosed with ASD by 0.39 percentage points, which is roughly 22% of the mean diagnosis rate of 1.8 percentage points. Similarly, when we use the occupation measures we find that a father at the 90^{th} percentile of the systemizing index distribution is 0.22 percentage points (12% of the sample mean) more likely to have a child diagnosed with ASD than a father at the 10^{th} percentile of the distribution.

Regardless of specification or of the particular measure of systemizing that we use, we find no role for assortative mating on ASD diagnoses. In all cases, the coefficients on interaction terms between mothers' and fathers' systemizing are consistently small and statistically insignificant. This is not surprising given that we find no independent impact of mothers' systemizing on ASD diagnoses.

For our occupation-based measure of systemizing, we also estimate the relationships between ASD diagnoses and systemizing among maternal and paternal grandfathers. This approach, which mimics the small-scale research case-control study in Baron-Cohen et al. (1997), avoids issues of labor market selection of women into certain occupations. The results are remarkably consistent with those we obtain for parents – the paternal grandfather's level of

systemizing is related to the grandchild being diagnosed with ASD, but the maternal grandfather's level of systemizing has no independent effect. Compared to paternal grandfathers at the 10th percentile of the distribution of systemizing across occupations, paternal grandfathers at the 90th percentile are roughly 0.146 percentage points (8% of the sample mean) more likely to have a grandchild diagnosed with ASD.

I. Systemizing and ASD

A key link between characteristics of parents and ASD in children derives from the theory that ASD is the result of an excessively systemizing personality (e.g. Baron-Cohen, 2006). A person is a systemizer if he or she finds it easier to cope with "lawful" situations--situations where there are clear rules and laws, whereas "unlawful" situations that involve uncertainty and chaos are more difficult to handle. The idea behind this theory is that a typical systemizer will will be attracted to occupations and fields of education that involve lawful systems such as engineering, information technology, computer science and natural sciences. There is some empirical evidence supporting this sorting of systemizers into more technical occupations. Billington, Baron-Cohen, and Wheelright (2007) show that after accounting for gender, students with higher systemizing quotient (SQ) scores relative to empathizing quotient (EQ) scores (more details on SQ and EQ below) are more likely to major in physical sciences, while those with higher EQ relative to SQ are more likely to major in humanities. Wright, Eaton and Skagerberg (2015) find that systemizing explains a substantial portion of gender differences in some occupations. Finally, Manning et al. (2010) show using a survey with a simplified version of SQ and EQ that the largest SQ – EQ differences for both males and females were for engineering/R&D and information technology.

Baron-Cohen (2006 theorizes that systemizing is genetically inheritable, so that parents who are systemizers are more likely to have children who are also systemizers and have increased likelihood of exhibiting symptoms of ASD. Moreover, Baron-Cohen (2006) argues that assortative mating of systemizers will lead to an increased prevalence of extremely systemizing offspring. He further argues that an extremely systemizing individual loses the ability to navigate uncertainty, a key characteristic of ASD. Altogether, this leads to the conclusion that parents who are systemizers are more likely to have children with ASD, and that assortative mating of systemizers leads to even higher ASD rates in children.

The empirical evidence is still sparse for the relationship between systemizing parents and ASD in children. Mothers and fathers of children with autism are more likely to score high on systemizing tests (Baron-Cohen and Hammer, 1997), maternal and paternal grandfathers of autistic children are disproportionately likely to be engineers (Baron-Cohen, et al., 1997), and students in engineering, physics or math are more likely to have autistic relatives (Baron-Cohen, et al., 1998). Windham et al. (2009) explicitly estimates the impact of parental occupation and assortative mating itself on autism prevalence. They conclude that ASD prevalence is higher among children whose mothers' occupation is "high-tech" relative to other professional occupations, but they find no statistically significant difference among fathers, and no effect of assortative mating on ASD diagnoses. On the other hand, Dickerson et al., (2014) conclude that fathers who work in healthcare or finance occupations are more likely to have children diagnosed with ASD than fathers in other occupations, but they find no relationship between mothers' occupations and ASD.

All of these studies either have small sample sizes or selected samples (or both). For example, Baron Cohen, et al. (1998) is a study of 1300 undergraduates (and self-reports of characteristics of their family members) at Cambridge University. Windham et al. (2009), is a study of 248 children with ASD matched to 659 case controls all drawn from the San Francisco Bay Area. And Dickerson et al., (2014) study a sample of 211 children diagnosed with ASD and 78 controls from the Houston area.

Given the small-scale and somewhat idiosyncratic nature of these previous studies, and the fact that the results are not fully consistent across them, the jury is still very much out on whether and how systemizing of parents (or grandparents), at least as it manifests in occupational choice, is related to ASD diagnoses in children, and whether this association is magnified by assortative mating. By harnessing the richness of the Danish registry data, we are able to overcome these limitations. We have information on diagnosis of ASD and Autism for virtually all children born in Denmark between 1995 and 2010, and we are able to construct and utilize multiple measures of systemizing of parents and paternal grandparents that leverage *both* educational and occupational choices.

II. Autism Diagnosis and Service Provision in Denmark

Before describing our data and empirical strategy, it is useful to provide some details on how Autism Spectrum Disorders are diagnosed in Denmark and to provide some information on the Danish health system. The majority of Danish health care services, including the diagnostic evaluations and treatment of autism, are free of charge, and all citizens have equal access (Danish Ministry of Health and Prevention, 2008). If parents or other caregivers (e.g., teachers, school psychologists, and social service providers) notice that a child is not following the typical developmental path, they may request that the child be evaluated by a medical professional. The first step in the diagnosis of very young children often involves a visit to the general practitioner, who acts as a gatekeeper for specialist treatment.[3] The general practitioner discusses the caregiver's concerns, collects information on the child's medical history (e.g., prenatal and perinatal conditions, hereditary dispositions) and conducts a preliminary assessment of the child's development, focusing on criteria outlined by the *International Classification of Diseases* (ICD) diagnostic manual. If the general practitioner's initial evaluation raises concerns about a mental health problem, the child is referred from primary care to specialist care. Given that there are no screening tools that can unequivocally detect ASD, the medical guidelines recommend that all children with suspected ASD tbe referred to a specialist (Sundhedsstyrelsen, 2001).

A child who is referred to specialist care is evaluated by an interdisciplinary team that consists of a child and adolescent psychiatrist, a clinical or educational psychologist, and often a speech and language therapist.[4] Parents usually have very limited power in choosing the specialist due to historically long waiting times. According to Daley et al. (2015), up until the 2000s, "it was not uncommon for children to wait up to two years to be seen in regional child and adolescent psychiatry departments" [p. 19]. Even in recent years, waiting times remain an important problem: in 2005, 35% of children had to wait at least 3 months before their first psychiatric evaluation and 1% had to wait more than a year (Sundhedsstyrelsen, 2015).

[3] School-age children are typically referred to a specialist by school psychologists.

[4] Children referred to specialists can be treated by psychiatrists at regional psychiatric hospitals or in private practice (under contract with the Danish Regions). General practitioners refer patients to private practices only if regional hospitals are overbooked. Hence, the bulk of child and adolescent psychiatric care is provided by regional hospitals. Currently, there are only 16 private psychiatry practices that have a formal agreement with the Danish Regions. These private practices cared for 4,049 patients in 2011. Hospital-based psychiatric wards, on the other hand, provided care for 22,788 children in the same year. It is possible to see a specialist without a referral, but these specialists work at private psychiatric clinics that do not contract with the Danish regions. In this case, patients have to cover the fees of these providers out of pocket. For more details on the structure and organization of mental health services in Denmark, see Chapter 3 in Daley et al. (2015).

The assessment by the interdisciplinary team includes a structured observation, a diagnostic interview, a psychological examination, and a medical examination.[5] Structured observation refers to a 30-60 minute evaluation of the child in which the examiner checks the child's social and communication skills through a series of structured and semi-structured tasks. The assessment is done using autism-specific instruments, such as Autism Diagnostic Observation Schedule (ADOS). The diagnostic interview involves collecting the child's full developmental history through a structured interview of the parents. Medical guidelines in Denmark recommend the interview to be carried out using autism-specific tools, such as the Autism Diagnostic Interview-Revised (ADI-R). The purpose of the psychological examination is to create a cognitive profile of the child and to examine the child's learning strategies. Different neuropsychological tests are used depending on the child's level of development and language impairment. Finally, a physical examination is conducted. The medical exam always includes the measurement of the head circumference and a screening for sensory defects, but it can also include an examination of vision and hearing and an assessment of signs of specific comorbidities associated with ASD (e.g., neurological examination for epilepsy, examination of the skin for tuberous sclerosis). A diagnosis of ASD is made if the child presents developmental and behavioral features consistent with criteria outlined by the *International Classification of Diseases*.

Children who are diagnosed with ASD are entitled to free medical care. ASD care is tailored to the specific needs of each child and consists of behavioral therapy and pharmaceutical treatment. The pedagogical and psychological treatments provided to children aim to help them acquire new skills and to ultimately function independently in everyday life. Therapies for children with severe development delay focus on language development and skills such as imitation, attention, and play and exchange. Treatment of high functioning ASD children targets other skills such as social interactions and self-help. While there are no specific pharmaceutical drugs used in treatment of ASD, children with ASD receive pharmaceutical treatment for psychiatric and somatic comorbidities (e.g., depression, ADHD). In rare cases, children may be prescribed antipsychotic drugs to address aggressive behavior. In Denmark, Risperidone is the only antipsychotic drug currently approved for treatment of aggressiveness in children with ASD, and only for children who are at least 6 years old.

[5] For a description of autism care in Denmark, see Videnscenter for Autisme (2006).

Children with ASD are also eligible to receive special education. The type of special education is determined in consultation with the child's parents after the psychological assessment. If the child needs fewer than 9 hours of special needs education per week, (s)he is placed in mainstream classrooms with pullout time with a special needs teacher. If the child needs at least 9 hours of special needs education per week, then instruction takes place in remedial classes or at a special-needs school.

Finally, parents of children with ASD can apply for government support in accordance with the Danish Social Service Act. While parents are generally provided some counseling when a child receives a diagnosis of ASD, they can ask for additional funds to enroll in courses to understand their child's behavior, to create a family environment conducive to their child's progress, and to deal with the stress of caring for a disabled child. They can also request compensation to cover the direct costs of caring for a child with ASD (e.g., technical equipment needed at home, additional costs associated with special dietary restrictions, additional costs associated of hired professional help) as well as the indirect costs in the form of lost earnings. Finally, parents can request to have non-financial resources, such as professional childcare at specialized institutions.

III. Data and Descriptive Statistics

Our primary data is the Psychiatric Central Research Register (PCRR). Initiated in 1970, PCRR is an electronic record of patients treated at psychiatric departments in Denmark.[6] Beginning in 1995, data on outpatient visits and emergency room contacts were added. The dataset includes clinical information typically provided by discharge abstracts: primary diagnosis, admission and discharge date of inpatient visits, start and end date of outpatient treatments (including emergency room visits), and mode of admission (acute or planned). Between 1970 and 1993, diagnostic information was coded according the *International Classification of Diseases*, Eighth Revision (ICD-8). Since 1994, diagnoses are based on the *International Classification of Diseases*, Tenth Revision (ICD-10). Our main outcome variable is an indicator for having ASD. Individuals diagnosed with ASD were determined by ICD-10 codes of F84.0, F84.1, F84.3, F84.5, F84.8, and F84.9. This covers autism, atypical autism, childhood disintegrative disorder, Asperger's disorder, and other pervasive development disorders.

[6] See Mors et al. (2011) for a detailed description of the PCRR.

Lauritsen et al. (2010) assessed the ASD diagnosis measures in the PCRR and found that they exhibited high levels of construct validity. The PCRR registry is linked to a series of other registers that provide us with family linkages between children and their parents and grandparents, birth records, education levels, employment, and basic demographics (from population registers).

We focus on four measures of ASD incidence. Our primary outcome is whether a child is diagnosed with ASD at any age. We also measure diagnosis with ASD by age 8, restricting to birth cohorts where we observe the child through age 8 (1995 – 2006), and Autism diagnosis at any age.[7] We include cohort fixed effects in all specifications in order to address the different age profiles of cohorts due to time-censoring of the data as well as changes in underlying diagnosis patterns.

Our main independent variables capture parental or grandparental systemizing personality traits. In developmental psychology, the Systemizing Quotient (SQ) test described by Baron-Cohen et al. (2003) is the most widely-used measure of whether a person has a systemizing personality. An SQ test consists of questions intended to measure individual tastes for concepts such as attention to detail, inductive reasoning, and activities with well-defined rules.[8] For example, affirmative answers to the following questions increase measured SQ scores:

- "If I had a collection, it would be highly organized."
- "I am fascinated by how machines work."
- "I can easily visualize how highways in my region link up."

In contrast, affirmative answers to the following questions reduce SQ scores:

- "I find it difficult to understand information the bank sends me on different investment and saving systems."
- "I do not enjoy games that involve a high degree of strategy."
- "When I'm in a plane, I do not think about the aerodynamics."

[7] Note that since we only know the year of birth, we define age as the calendar year the diagnosis is observed minus the calendar year the student is born. So if we observe a child as being 8 years old, his/her true age is actually between 7 (e.g. born on December 31, 1995 and diagnosed on January 1, 2003) and 9 (e.g. born on January 1, 1995 and diagnosed on December 31, 2003) years old.

[8] Baron-Cohen et al. (2003) list the full set of the questions on the SQ tests.

Relatedly, there is also an Emphasizing Quotient (EQ) test that seeks to measure how well individuals empathize with others' situations (Baron-Cohen and Wheelright, 2004). Baron-Cohen and colleagues provide evidence that autism is partially a function of the difference between these measures, where those with high SQ and low EQ are more likely to exhibit symptoms of ASD (Baron-Cohen, et al., 2003; Wheelwright, et al, 2006). In general, it is difficult to match EQ to characteristics of field of study and occupations since they tend to relate to social interactions, rather than skills or abilities.[9] Hence we focus on systemizing in this study.

The Danish register data do not include direct measures of systemizing, so we pursue two alternative strategies for identifying the extent to which an individual has a systemizing personality type. The first is based on an individual's educational field, and the second is based on an individual's occupation.

In order to determine whether an educational field attracts those with systemizing personalities, the study authors examined every field listed under "highest level of education[10]" in the Danish for people who complete upper secondary high school, vocational schooling, or college.[11] In total, there are 4,131 distinct fields of education. Each of the authors provided a simple "yes" or "no" indicator for whether he or she thought the field was a systemizing field. In some cases, an author left the answer blank. Every "yes" vote was given a score of 1 while "no" or missing values were given scores of 0. Any field with at least 3 "yes" votes (a majority of the authorship) was identified as systemizing.[12] Ultimately, this provides us with 734 systemizing fields (18 percent of all fields). In future versions of this study, we will test the sensitivity of this rule to requiring a field have scores of 2 or higher, scores of 4 or higher, and so on. It is important to note that we made these determinations prior to observing how ASD diagnoses in the registry data correlate with specific educational choices. Figure 1 provide a breakdown of how our classifications match with general educational fields. The distribution matches well to

[9] A list of questions that make up the Empathizing Quotient are provided in Barron-Cohen et al. (2003) and Wheelwright et al. (2004).

[10] Data on the highest level of completed schooling are drawn from The Education Register. It is based on administrative school records except for individuals who completed their education before 1974 and for immigrants with no schooling in Denmark. For these last two groups of individuals, self-reported schooling information is collected from the 1970 Population and Housing Census and from Immigrant Censuses. Jensen and Rasmussen (2011) detail the Education Registers in Denmark.

[11] For individuals with less than an upper secondary education, such as those with only an 8th grade education, the information on field of study is sufficiently general that we viewed it as uninformative for determining whether the field is indicative of systemizing traits.

[12] A table of how each author evaluated the education fields can be provided upon request.

our priors. Parents in systemizing fields are more likely to be in science/technology/math and engineering while non-systemizers are concentrated in business, arts/humanities/education, trades/manual labor/services, and health. Nonetheless, these categorizations are not exclusive. There are a large number of business fields that we classify as systemizing as well as a substantial set of trades/manual labor/service fields.

For occupation, we make use of additional data outside the registries to inform our classifications. In particular, we use data from the Occupational Information Network (O*NET) survey of employers undertaken by the U.S. Department of Labor, Employment and Training Administration.[13] This survey samples U.S. employees in order to measure the importance of a variety of knowledge bases, skills, and abilities for a large number of occupations. To incorporate the O*NET information, each author first evaluated each knowledge, skill, and ability (KSA) question for systemizing, giving a rating of -1 (anti-systemizing), 0 (neutral), or 1 (systemizing) to each KSA. The totals were then summed over all five authors, providing a KSA systemizing index that ranges from -5 to 5 for each of the 120 KSAs in the data. A list of the KSAs and how each author scored them is provided in Appendix Table A1. For example, the ability category "memorization" received a score of 5, indicating a highly systemizing job requirement, while the ability category "oral expression" received a score of -5, indicating that this job requirement is poorly-suited to those with systemizing personalities. As with education, all authors provided these scores prior to observing how ASD diagnoses in the registry data correlate with specific career choices.

In order to aggregate these KSAs to the occupation level, we turn next to the O*NET data, which includes survey responses from a sample of employees and employers in 809 separate occupations. Each respondent rates the importance of a particular KSA for the performance of their current job, on a scale from 1 ("not important") to 5 ("extremely important").[14] We use the average of these importance ratings across respondents in a particular occupation; for example, among the 27 respondents in the occupation "mathematicians", the

[13] All current and previous O*NET database releases are available at the database release archive: https://www.onetcenter.org/db_releases.html. We use measures from the O*NET version 10.0 below, but in future versions of this study we will average over multiple releases of the O*NET surveys.

[14] In addition to the importance of each KSA for a particular occupation, respondents also reported the level of the particular KSA that is required for that occupation. In practice, the responses for both "levels" and "importance" are similar across all KSAs, so we focus on the "importance" measure. Moreover, the "importance" rating is arguably a better measure of systemizing as it is intended to reflect preferences rather than actual capabilities.

average importance of "social perceptiveness" was 2.37, while the average importance of "complex problem solving" was 4.74. We then construct an occupation-based measure of systemizing as the weighted sum of our constructed KSA-level systemizing indices across all KSAs, using the average importance scale of each KSA as weights:

$$Occ\_Syst\_Index_j^{US} = \sum_{k=1}^{120} KSA\_Syst\_Index_k \times IM_{kj} ,$$

where *j* denotes occupation, *k* denotes the knowledge base (*K*), skill (*S*), or ability (*A*) question in the O*NET database, $KSA\_Syst\_Index_k$ denotes the KSA-level systemizing index, and IM_{kj} denotes the average importance rating of KSA *k* in occupation *j* from the O*NET data.

In order to merge the occupation-level systemizing indices to the Danish registry data, we use a crosswalk provided by the Institute for Structural Research at the University of Warsaw. These data convert occupation codes from Standard Occupation Codes for 2000 (SOC-00) used in the O*NET database to International Standard Classification of Occupations for 1988 (ISCO-88), which are the occupation codes used in Danish registries.[15] Unfortunately, the SOC-00 codes do not perfectly align with ISCO-88. In particular, there are a number of SOC-00 codes that match to multiple ISCO-88 codes and vice-versa. In order to convert the U.S. occupation index to Danish occupations, for each four digit ISCO-88 code we average over all matched SOC-00 codes so that

$$Occ\_Syst\_Index_i^{Den} = \frac{\sum_j^J Occ\_Syst\_Index_j^{US}}{J} ,$$

where *i* is the ISCO-88 code, *j* is a SOC-00 code matched to *i*, and *J* denotes the total number of SOC-00 codes matched to *i*. This gives us our final systemizing index for each occupation listed in the Danish registries.

The final step is to link the systemizing measures to the parents and grandparents through their occupations. Since occupations can change over time and are missing in periods when the individual is unemployed or has left the labor force, we average the systemizing index and systemizing percentiles over occupations listed in each year that the parent (grandparent) is

[15] This crosswalk is located at http://ibs.org.pl/en/resources/occupation-classifications-crosswalks-from-onet-soc-to-isco/. We use the Employment Classification Module (AKM) to infer an individual's occupation code. Initiated in 1976, AKM describes an individual's most important employment activity as of January 1 of each year. For more information, see Petersson et al. (2011).

between the ages of 25(40) and 34(59).[16] This helps maximize the number of individuals for whom we have systemizing data while ensuring that in most cases the systemizing scores are based on multiple years of data. Finally, we demean the systemizing index within fathers, mothers, paternal grandfathers, and maternal grandfathers and then divide by the *fathers'* standard deviation of the index. This normalizes each parent's or grandparent's systemizing index by the father's distribution in order to ensure that the systemizing indices for all parents and grandparents are on the same scale.

Our baseline regressions additionally control for characteristics that are known to be associated with the likelihood of ASD in children. In particular, we control for the gender of the child, parental age, marital status of parents at birth[17], father's gross personal annual income (including government transfers) at age 35[18,19], and indicators for parental field of study. We also control for indicators for parish of the child's birth registration to capture time-invariant geographic differences in the propensity to diagnose ASD.[20]

Our analysis sample includes all children born in Denmark between 1995 and 2010. We restrict our first cohort to 1995 to ensure that reporting and diagnosis of ASD remains stable during our study period.[21] In total, there are 1,069,647 children born during this period. Using unique individual identifiers (scrambled social security numbers provided by Statistics Denmark), we link these children to their biological parents and grandparents. We identify

[16] Parents (grandparents) are dropped from the sample if we never observe an occupation for them within the relevant age range. This primarily affects mothers.

[17] Demographic characteristics are obtained from the Population Register, which includes all individuals with permanent residence in Denmark on January 1st of each year. It contains a snapshot of demographic data on January 1st such as marital status, gender, date of birth, place of birth, place of residence, and citizenship. The data are updated annually. More details on this register are available in Pedersen (2011).

[18] Parental income information comes from the Income Statistics Register, which covers all Danish residents aged 14 and above who are liable to pay taxes in Denmark for the entire year. It is an individual level panel dataset containing information drawn from final tax assessments filed with the Tax Administration. It includes more than 160 variables measured on an annual basis such as salary income, taxes, public transfer payments, capital income, and private pension contributions. Baadsgaard and Quitzau (2011) provide an overview of this register.

[19] For fathers in the data who are not yet 35 or whose earnings are missing at age 35, we predict age-35 income by estimating the raw age-earnings profile of income for the sample and then adding predicted growth in earnings from this profile to the latest observed earnings for that person.

[20] The specific birth location variable we use is "foedreg_kode." Ninety-six percent of births are registered birth locations we can identify. These locations were originally based on ecclesiastical boundaries but now serve solely to designate administrative regions. In our sample there are a total of 2219 unique birth registration locations.

[21] As noted before, diagnosis of ASD changed from ICD-8 to ICD-10 starting in 1994. In addition, PCRR was expanded in 1995 to include outpatient and emergency room contacts. Previous research found that these two reporting changes jointly explain 60% of the rise in ASD diagnosis among children born between 1980 and 1991 (Hansen et al., 2015).

parents using the Danish Medical Birth Register (MBR), which includes information on all births in Denmark since 1973.[22] Mother's identifier is available for all children. If the mother is married, her husband is assumed to be the father and as such his identifier is recorded in the data. If the mother is unmarried, then the identifier of the father is available if the father has claimed the child. In our sample, 98.8% of children are matched to their fathers. Grandparents are defined using the Population Register as the legal parents of the parents at the birth of the child. We are able to match 89.9% of the children to their maternal grandfather and 88.4% to their paternal grandfather. Overall, our final sample includes 1,023,494 children matched to both parents and 860,447 matched to both grandparents.

Our systemizing trait variables are based on field of education and primary occupation. Parental field of education is missing for 2.6% of fathers and 1.9% of mothers. The corresponding numbers for grandparents are 18.5% for paternal grandfathers and 15.8% for maternal grandfathers. The field of education is missing at a slightly higher rate for fathers (2.7%) and paternal grandfathers (18.8%) of children with ASD and at a slightly lower rate for their mothers (1.2%) and maternal grandfathers (14.5%). With respect to our systemizing index based on occupations, 81% of children in our sample have a father with a systemizing index while 86% have a mother with an index. Of children who can be matched to their paternal grandfather, 64% have a systemizing index for that grandfather. Similarly, the rate is 70% for maternal grandfathers. These rates are slightly lower for children diagnosed with ASD at 79%, 86%, 59%, and 66% for fathers, mothers, paternal grandfathers, and maternal grandfathers, respectively.

Finally, some of our additional control variables are missing for a small number of observations: mother's age (0.03%), father's age (0.55%), mother's marital status at birth (1.06%), father's income at age 35 (6.25%). Overall, these restrictions leave us with a sample of 692,886 observations when using the education based systemizing index and 738,126 observations when using the occupation based systemizing index.

Table 1 provides descriptive statistics for the overall analysis sample, as well as by parental systemizing status. Column (1) shows means and standard deviations (in parentheses) based on the full sample of over 1 million Danish children with matched fathers and mothers. In this sample, roughly 1.8 percent of all children are diagnosed with ASD, 0.6 percent are

[22] For more information, see Knudsen and Olsen (1998).

diagnosed with autism, and 0.9 percent are diagnosed with ASD by age 8. For the "diagnosis by age 8" measure, we restrict the sample to include only those children born between 1995 and 2006, guaranteeing that we observe these children until at least their 8th birthday. We also show the mean overall ASD diagnosis rate in the "age 8 sample", i.e., without requiring that the diagnosis occur before age 8. The mean of 2.1 percent implies that over half of the children in the 1995-2006 birth cohorts were diagnosed after age 8.

The remaining columns in the table show summary statistics conditional on realizations of our measures of systemizing. Column (2), for example, limits the sample to all children whose father was in a systemizing educational field, but whose mother was not. This reduces the sample to 117,525 children. Columns (3), (4), and (5) limit the sample to all children who had only a mother in a systemizing field, both parents in a systemizing field, and neither parent in a systemizing field, respectively. A comparison of the top row in columns (4) and (5) implies that, compared to a child with no systemizing parents, a child with two systemizing parents has a 0.003 (= 0.019 - 0.016) higher probability of being diagnosed with ASD.

The remaining rows of the table show means and standard deviations for a range of observable characteristics of the parents and the children. As a comparison across columns shows, some of these measures vary importantly by parental systemizing. For example, average father's gross taxable income at age 35 is 507,927 Kroner (inflation adjusted to 2010; $83,300 at June, 2010 exchange rates) in column (4), compared to 406,353 ($66,641) in column (5). This is in comparison to average male annual earnings of 483,132 Kroner in 2011.[23]

Finally, columns (6)-(9) mirror columns (2)-(5) but base the systemizing measure on occupation rather than education. Specifically, here we define an occupational field as "systemizing" if its occupational index is greater than the median index *among fathers* in the sample, regardless of whether the mother or father is being measured. In our empirical specifications below, we will use the continuous occupational index rather than this binary measure.

V. Empirical Strategy

[23] Denmark in Figures, 2014. Available at http://www.dst.dk/Site/Dst/Udgivelser/GetPubFile.aspx?id=17954&sid=dkinfigures2014.

In order to measure the relationship between parental systemizing traits and diagnoses of ASD, we begin by estimating equations of the form

(1) $$ASD_i = \beta_0 + \beta_1 SI\_M_i + \beta_2 SI\_F_i + \beta_3 (SI\_M_i \times SI\_F_i) + X_i\gamma + \varepsilon_i \,,$$

where ASD_i is a dummy variable equal to 1 if child *i* is diagnosed with an Autism Spectrum Disorder (or Autism in some models), SI_M_i is a measure of whether the child's mother has systemizing personality traits, as measured by either educational field or occupation, and SI_F_i is an analogous measure for the child's father. The vector X_i includes family and environmental characteristics that represent important risk factors for ASD as described above.

Specification (1) includes the interaction term $(SI\_M_i \times SI\_F_i)$ in order to assess the impact of assortative mating on the basis of systemizing on ASD prevalence. As noted above, several authors, including Baron-Cohen (2006), Baron-Cohen et al. (1997), Roelfsema et al. (2012), and Windham et al. (2009), have speculated that a significant portion of ASD diagnoses are generated from assortative mating. Below we also report estimates of specification (1) that exclude the interaction term, in order to focus directly on the main effects capturing the role of parental transmission.

A potential obstacle to obtaining interpretable estimates of specification (1) stems from the possibility that female occupational and educational field choice may be distorted due to barriers to women's educational and occupational choices, and possibly through nonparticipation in the labor market. Of particular concern is the possibility that access to systemizing fields might be limited for women, especially among older cohorts. If so, women with systemizing personalities might have historically been excluded from systemizing fields such as engineering or computer science, implying that our systemizing indices do not capture the true preferences and aptitudes of mothers in our sample. In order to address this potential obstacle, we take advantage of the fact that the Danish registries include links from children to their grandparents, for whom we observe detailed data on educational and occupational choices. Based on these data, we create systemizing indices for both maternal and paternal grandfathers, SI_MGF_i and SI_PGF_i, respectively, and estimate a variant of specification (1):

(2) $$ASD_i = \beta_0 + \beta_1 SI\_MGF_i + \beta_2 SI\_PGF_i + \beta_3 (SI\_MGF \times SI\_PGF_i) + X_i\gamma + \varepsilon_i \,.$$

In specification (2), we use measures of systemizing among grandfathers to proxy for systemizing among parents, allowing us to circumvent issues related to constraints on women's choices. We note that we are not the first to use a variant of this strategy, as previous authors

have argued that the maternal and paternal grandfathers of autistic individuals are disproportionately likely to be engineers (e.g., Baron-Cohen, et al., 1997). Unfortunately, there are substantial differences over time in the evolution of educational fields, which leads us to classify far fewer educational fields as systemizing for grandfathers. Further, grandfathers have considerably lower rates of completion of secondary school, limiting our ability to assess their systemizing status. In particular, while we are able to identify whether a father's field is systemizing for 75% of children, we are only able to do so for the paternal grandfather's field for 37% of children (and for 39% of children for the maternal grandfather's field). Further, while 25% of fathers' fields and 20% of mothers' fields are systemizing, only 3% of grandfathers' fields are systemizing.

Because of the difficulty in comparing educational fields over time, we restrict our analysis of specification (2) to systemizing based on occupation. In this case we are much better able to observe whether grandfathers are systemizers. In fact, the distribution of the systemizing index for both maternal and paternal grandfathers are very similar to those for fathers. This is highlighted in Figure 2, which shows that the grandfathers' distributions as a percentile of the fathers' distribution are very similar while the mothers' distribution is skewed towards less systemizing occupations. In fact the mean systemizing index for fathers is 63.2 (standard deviation of 45.1) while the means for paternal and maternal grandfathers are 63.2 (43.1) and 63.6 (43.0), respectively. On the other hand, for mothers the mean is 19.4 (35.0). There is also a sizable correlation between father's systemizing and paternal grandfather's systemizing indices of 0.20. For mothers and maternal grandfathers the correlation is, not surprisingly, considerably lower at 0.06.

VI. Results

VI.1 Education as a Proxy for Systemizing

Table 2 presents the results from linear probability regressions as described in Equation (1), where we estimate the relationship between the probability that a child is diagnosed with ASD and parents' systemizing propensities. In this table, we use as a measure of systemizing the binary designation determined by the parents' fields of education.

Column (1) presents baseline results where we include the binary systemizing designation for the father and mother of the child separately, in addition to controls for the

child's sex, parents' age, mother's marital status, child's birth year, and parents' educational attainment. Some of these controls are known to be risk factors for ASD diagnoses (e.g. child's sex – Werling and Gerschwind, 2015; father's age – Lauritsen et al., 2005). Others reflect socioeconomic proxies that can affect diagnosis rates (e.g. educational attainment of parents – Daniels and Mandell, 2014), while the birth year fixed effects control for secular changes in ASD diagnosis rates that may result from true changes in ASD across cohorts or may reflect rising diagnosis rates for the same underlying conditions.[24] All coefficients and means in the table are multiplied by 100 so that the estimates are reported in terms of percentage points.

Estimates of the baseline model in column (1) imply that having a systemizing father increases the probability of ASD diagnosis by 0.35 percentage points (nearly 20 percent of the sample diagnosis rate of 1.8 percent). In contrast, the coefficient on the indicator for the mother having an educational background in a systemizing field of education is only about one-fourth the size of the coefficient of the father and is not statistically significant.

In column (2) of Table 1 we add fixed effects for the location of the child's birth registration. These fixed effects control for geographic differences in environmental factors that could affect ASD propensity and geographic variation in the propensity of physicians to diagnose ASD (or parents to seek out diagnoses or treatment). The coefficients on both the father and the mother systemizing are very similar to that in Column 1. In column (3) we include the father's income at age 35, which can be thought of as a good proxy of father's lifetime income[25], and we include interactions for the educational attainment of mothers and fathers. These extra covariates are meant to help further control for the socioeconomic status of the family. Again, the results look very similar to those in column (1).

Columns (4)-(6) of Table 2 replicate the specifications of the first three columns of the Table, but each column also includes an interaction term for the father and mother's systemizing proxies. The coefficients on both the father's and mothers' systemizing proxies are quite robust across the columns, and quite similar to those in Columns (1)-(3), and the coefficient on the interaction between the two proxies is small and statistically insignificant. That is, we find no evidence suggesting that assortative mating by systemizers can increase the propensity for a child to be at the more extreme end of the systemizing spectrum and thus be clinically eligible

[24] Full regression results can be found in Appendix Table A2.
[25] See, e.g., Haider and Solon (2006).

for a diagnosis of ASD. This contrasts with some of the previous well-known smaller-scale studies such as Baron-Cohen et al. (1997), Baron-Cohen and Hammer (1997), and Dickerson et al (2014) but is consistent with the findings of Windham et al. (2009), which uses a considerably larger sample than the other studies. Windham et al. (2009) also find that their systemizing measure for the mother is positive and statistically significantly related to ASD diagnoses in children.

In Table 3, we repeat the analysis of Table 2, but we consider three somewhat different outcomes: the propensity of a child to be diagnosed with ASD by age 8 (Panel A), the propensity to ever be diagnosed in the restricted birth cohorts of 1995-2006 that generate Panel A (Panel B), and the propensity of a child to be diagnosed with Autism, a more narrow and severe diagnosis within ASD (Panel C).

The results in Panel A, for the outcome of diagnosis of ASD by age 8, again show that there is an increased probability of ASD diagnosis for children whose fathers are in systemizing education categories, but that mothers' education categories play no role. Once again, there is no evidence of assortative mating increasing ASD diagnosis rates. The ASD diagnosis rate in this sample (0.009) is much smaller than in Table 2, but relative to the relevant sample means, the impact of having a father in a systemizing education field is quite similar to that of Table 2. For example, in column (6) of Panel A, the coefficient on having a systemizing father implies an increase in the probability of ASD diagnosis of 23 percent (0.208/0.9), while in column (6) of Table 2, the analogous increase is 21 percent (0.0038/0.018).

Appendix Table A2 reports all the coefficient estimates from the regressions that are used to create Panel A. We report these extended estimated coefficients for this outcome variable (rather than for the regressions in Table 2 that use the full sample) because so many of them (age of parents, birth year, income at age 35, etc.) reflect important cohort differences that affect ASD diagnoses in the full sample that arise due to censoring, an issue that is not present in Panel A when we restrict the sample to ASD diagnosis by age 8. (However, as we discuss in further detail below, it is worth noting that girls are less likely to be diagnosed with ASD by age 8). The fraction of children diagnosed with ASD by age 8 is monotonically increasing in father's age at birth, although none of the coefficients are individually significant. Having a mother aged between 31 and 35 at birth (relative to a mother aged 25 or below) is associated with a decline in the fraction of children diagnosed with ASD by age 8 between 0.10 percentage points (11

percent) and 0.16 percentage points (18 percent), depending on specification. Father's income is associated with a decline in the fraction of children diagnosed with ASD by age 8, but such an association is significant only when father's income at age 35 is "high enough" (i.e. belongs to the 5th decile or higher of the father's income distribution at age 35). Having the father in the highest income decile is related to a decline in the fraction of children diagnosed with ASD by age 8 equal to 0.4 percentage points, the largest coefficient of the father's income distribution, and twice as large in absolute value than the coefficient of the variable indicating that the father's income at age 35 belongs to the 9th decile of the father's income distribution deciles (columns (4) and (6)). We do not find a significant relationship between parents' level of education and the fraction of children diagnosed with ASD by age 8, in any specification. Children's birth year is positively and significantly associated with the probability of ASD diagnosis, and the magnitude of the coefficient increases every year. Given that the sample is restricted to children who we observe to have reached at least age eight, and given that the dependent variable is defined to be a diagnosis of ASD by age eight, these coefficients represent a true difference in the propensity of diagnosis across these annual birth cohorts, and most likely reflects changing diagnostic patterns over time (consistent with other findings in Denmark, such as in Parner et al. (2008).)

Panel B of Table 3 reports coefficients from regressions where the outcome, as in Table 2, is diagnosis of ASD at any age, but we restrict the sample to the same children used in Panel A. That is, children for whom we observe information beyond age eight, and who are diagnosed with ASD beyond that age as well, will be coded as having a positive ASD diagnosis. This raises the rate of overall diagnosis, as a large fraction of children in these birth cohorts were, in fact, diagnosed at a later age. While the point estimates are higher than in Panel A, this is entirely due to the higher overall incidence. Relative to the dependent variable mean the estimates are remarkably similar. Having a systemizing father only increases ASD diagnosis by between 17% and 22% of the mean ASD rate in Panel A and by between 18% and 22% in Panel B.

Finally, in Panel C we consider specifications in which the outcome is diagnosis of Autism at any age. The rate of Autism in our sample is only a third as large as that of ASD, and yet we still find robust and relatively stable evidence across the specifications that it is father's systemizing field of education that matters, and that (conditional on the other covariates) mothers' field plays no role. The coefficient estimate of 0.102 on father's systemizing field in

Column (3) implies a percentage increase in Autism diagnosis probability of 16% relative to the sample mean diagnosis rate of 0.006.

VI.2 Occupation as the Basis for the Systemizing Measure

Tables 4 and 5 report estimates of our empirical specifications when considering parents' occupation as the basis of the systemizing measure we are using. [26] The specifications in each column parallel those in Tables 2 and 3. In this case our measure of systemizing is expressed as a linear index that is scaled from 1 to 100. The estimates that we report in Tables 4 and 5 on the systemizing variable are multiplied by 100 for clarity. The results suggest that once fixed effects for location of the child's birth are included in the regression, the higher the index of fathers' systemizing occupation is, the more likely a child is to be diagnosed with ASD, and the coefficient itself is fairly stable across the columns that include the parish of birth fixed effects. In Table 4, the coefficient estimate in Column (6), the most saturated of the models, implies that a 50 percentage point increase in the father's systemizing index (from, for example, the 25th percentile to the 75th percentile) raises the probability of an ASD diagnosis by about 0.11 percentage points (= 0.00228 × 50), or 6.3% of the baseline diagnosis rate of 1.8%.

As was the case in Tables 2 and 3, the coefficient estimates on mother's systemizing are much smaller than for fathers and are always statistically insignificant (the same is true of the coefficient on the interaction term for mothers and fathers). Appendix Table A2 reports the coefficients on the other covariates. Not surprisingly, most of the coefficient estimates for these other covariates are very similar to those in Appendix Table A1. One exception is the coefficients on educational attainment, which sometimes matter here but were not statistically significant in Appendix Table A1. This may be because educational attainment is correlated with underlying systemizing behavior; because it is also more correlated with the systemizing education fields used in Table 2 than it is with systemizing occupations, it has explanatory power in Table 4 where it did not in Table 2.

Table 5 reports the selected estimates when looking at the same outcomes and samples as in Table 3. Once scaled by the mean of the outcome variables, as was the case for education, the results in Panels A and B are similar to those in Table 4. For Panel C, where the outcome

[26] Children whose mothers are never observed to be participating in the labor market are dropped from the sample.

variable is the diagnosis of Autism, the coefficient estimates are unstable and statistically significant in only one of the six cases.

Tables 6 and 7 use another dimension of the data to test the relationship between systemizing and ASD diagnoses in children. As discussed in Section 5, the possibility exists that women's systemizing proxies do not fully account for the underlying of tendency of women toward systemizing behavior, perhaps because of barriers in the labor market to the entry of women into certain occupations, or barriers to certain types of education. The richness of the Danish registry data allows us to overcome this problem by conducting an analysis using information on maternal and paternal grandfathers, as in Baron-Cohen et al. (1997). Of course, grandfathers are from a different generation than the parents in our sample, and thus can have different observed distributions of education and occupation. Indeed, we find that the education systemizing distributions of grandfathers and fathers are very different, but the distributions of the indexes of occupation-based systemizing are much closer. As a result, we present results only using our measure of systemizing that is drawn from the occupation information.

Table 6 reports results that parallel Table 4, whereas Table 7 reports results that parallel Table 5. Because we cannot link all the children in our sample to their maternal and paternal grandfathers, the sample sizes in these tables are about half of that for the earlier tables that use parents' information.

Interestingly, the qualitative results are similar for grandparents and parents, and the magnitudes of the effects for paternal grandfathers are often higher than those for fathers. We still find no qualitatively important or statistically significant effect on diagnoses of ASD or Autism from the mother's side of the family, even when using maternal grandfathers' systemizing measures to account for the fact that women's occupations may not measure underlying systemizing behavior well.

In Tables 8-19, we explore heterogeneous impacts of parents' and grandparents' systemizing on ADS and Autism diagnoses by gender of the child. Tables 8 and 9 are the gender-specific versions of Table 2, Tables 10 and 11 are the gender-specific versions of Table 3, Tables 12 and 13 are the gender-specific version of Table 4, Tables 14 and 15 are the gender-specific versions of Table 4, Tables 16 and 17 are the gender-specific versions of Table 6, and Tables 18 and 19 are the gender-specific version of Table 7. In our data, as is documented elsewhere, boys are more likely than girls to be diagnosed with ASD and with Autism. Baseline

results in Tables 8 and 9 (column (1)) show that having a systemizing father as measured by field of education increases the probability of being diagnosed with ASD by 0.145 percentage points (17 percent of the sample mean) for girls and by 0.543 percentage points (20.5 percent) for boys. However, having a systemizing father as measured by field of education increases the probability of ASD diagnosis by age 8 for boys, but not for girls (Tables 10 and 11). Part of this result is due to the tendency of girls to be diagnosed later than boys.

For girls, we find that having a systemizing father as measured by our occupation-related measure increases the probability of ASD diagnosis in 3 specifications (columns (2), (3), and (6) of Table 12), but again, ASD diagnoses by age 8 and Autism diagnoses are not affected (Table 14). In contrast, the pattern for boys (Tables 13 and 15) mimics more closely the pattern we described earlier when looking at the combined sample (Tables 4 and 5). Finally, paternal grandfathers' systemizing never explains ASD (or Autism) in girls (Tables 16 and 18). Thus, the patterns described earlier using grandparents' information on the combined sample of boys and girls are driven entirely by the effects of paternal grandfathers' systemizing on ASD and Autism outcomes for only boys (Tables 17 and 19).

VI.3 Summarizing the Results

Across all of the regression results presented above, we find that systemizing behavior among fathers is meaningfully and statistically significantly related to higher incidence of ASD, while systemizing in mothers has no relationship to diagnosis rates in children (nor does the interaction between the systemizing of mothers and fathers). This is true when we define systemizing using a binary variable that is defined by fields of education that are related to systemizing, and it is true when we use an index of systemizing derived from characteristics of occupations. This result also holds when we restrict diagnoses to those that occur by age 8, but only for boys. It is true when we use information on fathers and mothers, and when we use information on paternal grandfathers and maternal grandfathers, but for the latter it is true only for boys. While it is well-known that there are gender differences in ASD and Autism, we know of no papers in the medical literature that establish a purely sex-linked mechanism through which ASD is passed from parents to children. Our evidence is consistent with such a finding, but is limited to one particular mechanism – systemizing – so other mechanisms may work through both maternal and paternal lines.

V. Conclusion

Using high-quality large-scale administrative data in Denmark, we test the hypothesis that parents with higher levels of systemizing traits are more likely to have biological children who are diagnosed with ASD. We construct novel measures of human capital systemizing traits based on parents' (and grandfathers') occupational and educational choices and show that for both measures, systemizing of fathers raises the probability of ASD in children conditional on other controls, whereas systemizing of mothers has no independent impact. As a result, our results show little scope for assortative mating of systemizing fathers and mothers to have an impact on ASD incidence in children, and indeed we find none. Since we can link not only children to parents, but also children to grandparents, we can also test for an impact of systemizing traits of paternal and maternal grandfathers on grandchildren. We again find that systemizing of grandparents raises ASD incidence through the father's side of the family and not the mother's, but we can only establish this link for boys.

These results lend credence to the theory (Baron Cohen, 2006) that systemizing exists on a spectrum and is heritable, although our findings suggest that the pathway by which this occurs is through fathers. Our results also show that it is indeed possible to identify proxies for systemizing via the education and occupation investment decisions that individuals make, decisions that are affected by important underlying heterogeneity across individuals (especially fathers).

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Figure 1 - Father's and Mother's Fields of Study by Systemizing

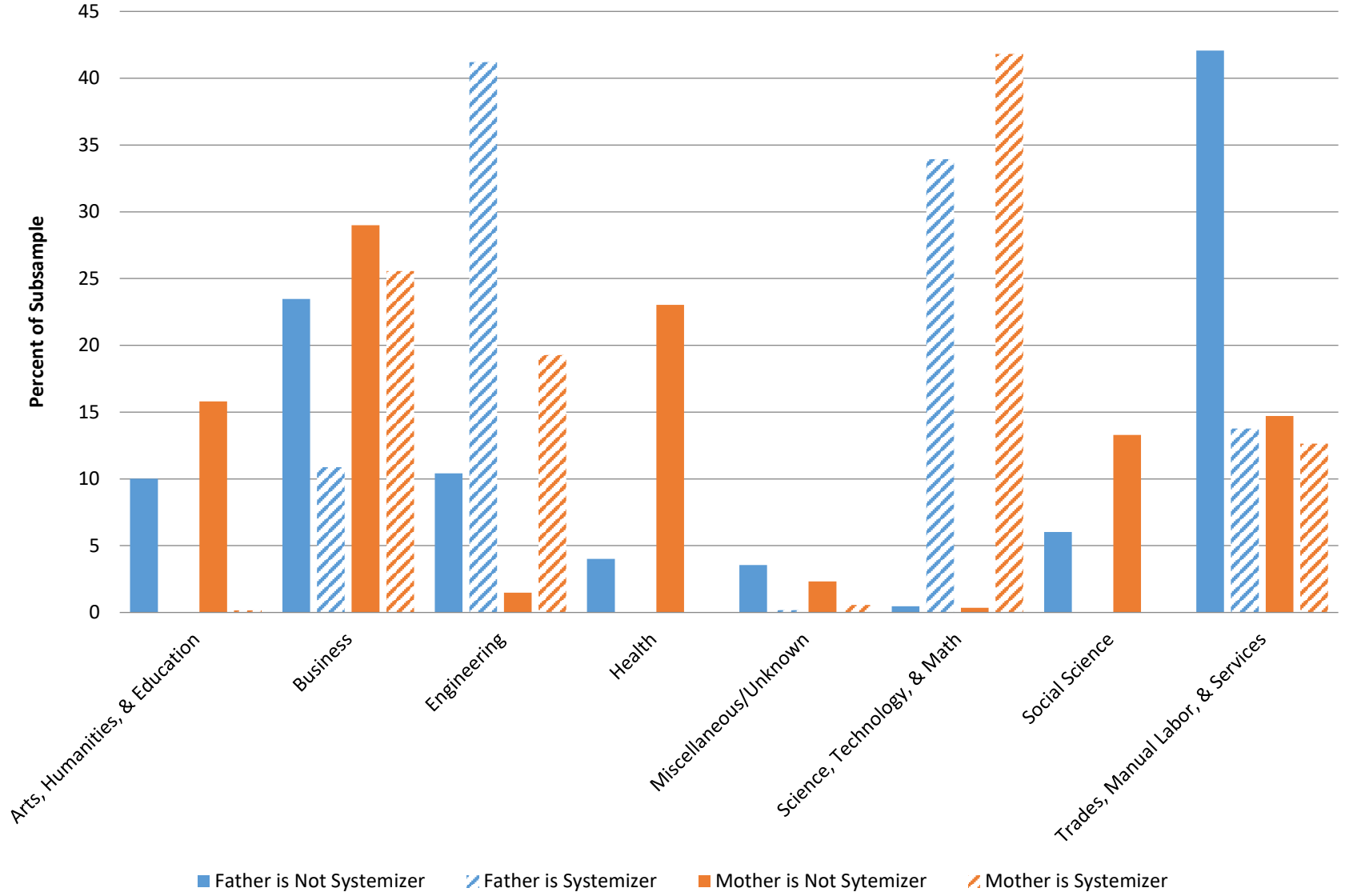

Figure 2

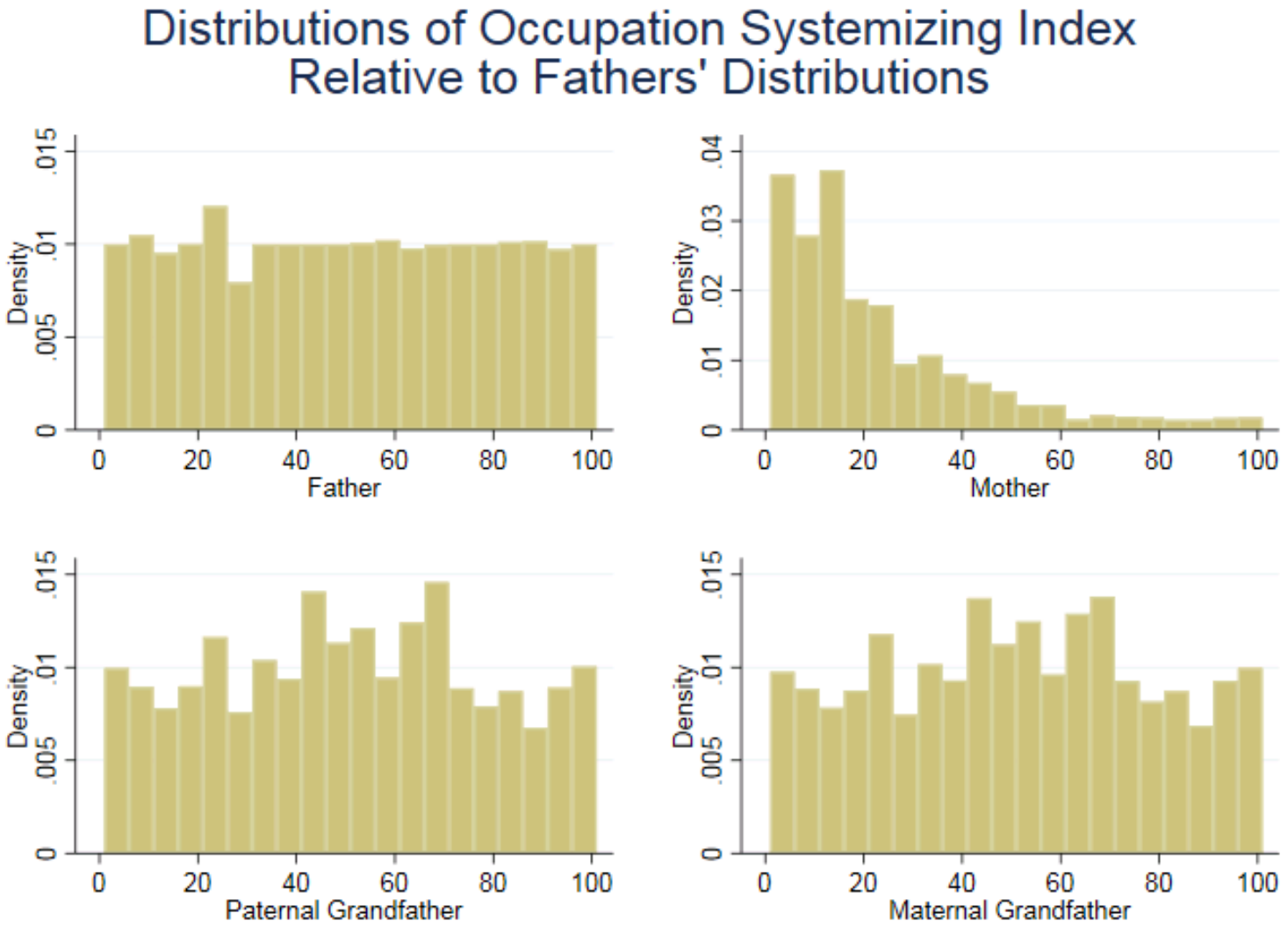
Distributions of Occupation Systemizing Index
Relative to Fathers' Distributions
Density
0
.005
.01
.015
0
20
40
60
80
100
Father
Density
0
.01
.02
.03
.04
0
20
40
60
80
100
Mother
Density
0
.005
.01
.015
0
20
40
60
80
100
Paternal Grandfather
Density
0
.005
.01
.015
0
20
40
60
80
100
Maternal Grandfather

Table 1. Summary Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Education Systemizing Indicator = 1				**Above Median of Occupation Systemizing Index**			
	All	**Dad**	**Mom**	**Both**	**None**	**Dad**	**Mom**	**Both**	**None**
Diagnosed with ASD^	0.018	0.018	0.016	0.019	0.016	0.018	0.019	0.019	0.016
	(0.132)	(0.134)	(0.125)	(0.137)	(0.124)	(0.132)	(0.135)	(0.137)	(0.127)
Diagnosed with Autism (F84.0)	0.006	0.005	0.005	0.006	0.005	0.005	0.005	0.007	0.005
	(0.075)	(0.074)	(0.070)	(0.075)	(0.070)	(0.071)	(0.071)	(0.081)	(0.072)
Diagnosed with ASD by age 8	0.009	0.010	0.009	0.010	0.008	0.009	0.010	0.009	0.009
	(0.096)	(0.101)	(0.093)	(0.101)	(0.092)	(0.093)	(0.098)	(0.094)	(0.096)
Diagnosed with ASD (age 8 sample)^^	0.021	0.022	0.019	0.023	0.019	0.021	0.022	0.021	0.020
	(0.143)	(0.146)	(0.136)	(0.149)	(0.136)	(0.142)	(0.147)	(0.144)	(0.138)
Child is female	0.487	0.487	0.489	0.486	0.487	0.487	0.491	0.481	0.487
	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)
Age of the father at time of birth	32.907	33.627	33.860	33.902	32.989	31.976	32.872	32.236	32.517
	(5.714)	(5.003)	(5.288)	(4.700)	(5.365)	(4.571)	(4.565)	(4.593)	(4.549)
Age of the mother at time of birth	30.271	31.464	31.396	32.087	30.608	29.949	30.964	30.297	30.597
	(4.786)	(4.257)	(4.212)	(3.891)	(4.407)	(4.323)	(4.229)	(4.336)	(4.191)
Mother married	0.511	0.577	0.582	0.633	0.516	0.489	0.537	0.515	0.520
	(0.500)	(0.494)	(0.493)	(0.482)	(0.500)	(0.500)	(0.499)	(0.500)	(0.500)
Father's gross taxable income at age 35^^^	390.414	476.452	423.101	507.927	406.353	398.222	424.917	401.987	418.782
	(233.590)	(233.998)	(262.994)	(235.321)	(240.953)	(210.068)	(262.025)	(233.273)	(253.498)
No. of Obs.	1,023,494	117,525	29,406	19,757	560,829	323,063	25,783	53,019	351,633

Standard deviations in parentheses

^ Diagnostic codes are: F84.0, F84.1, F84.3, F84.5, F84.8, F84.9

^^Means ever diagnosed with ASD at any age, but restricted to the 1995 – 2006 birth cohorts.

^^^1000kr (imputed when none observed)

Table 2. Diagnosis of ASD
Field of Parental Education is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Father's Field Syst.	0.351***	0.315***	0.390***	0.345***	0.308***	0.381***
	(0.048)	(0.047)	(0.046)	(0.050)	(0.050)	(0.049)
Mother's Field Syst.	0.083	0.062	0.066	0.061	0.037	0.033
	(0.060)	(0.061)	(0.061)	(0.072)	(0.075)	(0.075)
Mother × Father's Field Syst.				0.058	0.067	0.087
				(0.133)	(0.135)	(0.136)
Controls for: Child's Gender, Maternal and Paternal Age, Married Mother, Child's Birth Year	X	X	X	X	X	X
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
Mean Dep. Var. (Percentage Points)	1.8	1.8	1.8	1.8	1.8	1.8
No. of Obs.	692,886	692,886	692,886	692,886	692,886	692,886

Estimates are multiplied by 100.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3. Diagnosis of Either ASD or Autism,
Field of Parental Education is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by Age 8						
Father's Field Syst.	0.181***	0.168***	0.202***	0.191***	0.176***	0.208***
	(0.039)	(0.040)	(0.041)	(0.042)	(0.042)	(0.044)
Mother's Field Syst.	0.018	0.016	0.017	0.053	0.045	0.039
	(0.052)	(0.052)	(0.052)	(0.066)	(0.066)	(0.066)
Mother × Father's Field Syst.				-0.095	-0.078	-0.057
				(0.110)	(0.112)	(0.112)
Mean Dep. Var. (Percentage Points)	0.9	0.9	0.9	0.9	0.9	0.9
No. of Obs.	518,466	518,466	518,466	518,466	518,466	518,466
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Father's Field Syst.	0.418***	0.374***	0.469***	0.414***	0.369***	0.460***
	(0.059)	(0.058)	(0.057)	(0.062)	(0.062)	(0.061)
Mother's Field Syst.	0.072	0.042	0.050	0.058	0.023	0.020
	(0.074)	(0.075)	(0.075)	(0.089)	(0.092)	(0.092)
Mother × Father's Field Syst.				0.039	0.049	0.078
				(0.167)	(0.169)	(0.171)
Mean Dep. Var. (Percentage Points)	2.1	2.1	2.1	2.1	2.1	2.1
No. of Obs.	518,466	518,466	518,466	518,466	518,466	518,466
Panel C: Diagnosis of Autism Ever						
Father's Field Syst.	0.079***	0.078***	0.102***	0.079***	0.077***	0.101***
	(0.026)	(0.026)	(0.026)	(0.029)	(0.028)	(0.028)
Mother's Field Syst.	0.022	0.017	0.019	0.019	0.014	0.014
	(0.034)	(0.035)	(0.035)	(0.043)	(0.043)	(0.043)
Mother × Father's Field Syst.				0.007	0.009	0.013
				(0.073)	(0.073)	(0.073)
Mean Dep. Var. (Percentage Points)	0.6	0.6	0.6	0.6	0.6	0.6
No. of Obs.	692,886	692,886	692,886	692,886	692,886	692,886

Estimates are multiplied by 100. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ Diagnosed with ASD at any age, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same for each column as shown in Table 2.

Table 4. Diagnosis of ASD,
Parental Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Father's Occupation Syst.(percentiles)	0.027	0.218***	0.278***	-0.025	0.147*	0.228***
	(0.056)	(0.057)	(0.058)	(0.074)	(0.076)	(0.076)
Mother's Occupation Syst. (percentiles)	-0.128	-0.033	0.003	-0.267*	-0.226	-0.133
	(0.085)	(0.084)	(0.084)	(0.158)	(0.158)	(0.157)
Mother × Father's Occupation Syst. (percentiles)				0.002	0.003	0.002
				(0.002)	(0.002)	(0.002)
Mean Dep. Var. (Percentage Points)	1.8	1.8	1.8	1.8	1.8	1.8
Controls for: Child's Gender, Maternal and Paternal Age, Married Mother, Child's Birth Year	X	X	X	X	X	X
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
No. of Obs.	738,126	738,126	738,126	738,126	738,126	738,126

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5. Diagnosis of Either ASD or Autism,
Parental Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by Age 8						
Father's Occupation Syst.(percentiles)	-0.014	0.123**	0.155***	-0.010	0.122*	0.165**
	(0.049)	(0.050)	(0.051)	(0.066)	(0.065)	(0.066)
Mother's Occupation Syst. (percentiles)	-0.088	-0.022	-0.008	-0.076	-0.027	0.019
	(0.070)	(0.071)	(0.070)	(0.136)	(0.134)	(0.134)
Mother × Father Occupation Syst. (percentiles)				-0.000	0.000	-0.000
				(0.002)	(0.002)	(0.002)
Mean Dep. Var. (Percentage Points)	0.9	0.9	0.9	0.9	0.9	0.9
No. of Obs.	564,242	564,242	564,242	564,242	564,242	564,242
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Father's Occupation Syst.(percentiles)	0.050	0.268***	0.337***	0.020	0.213**	0.306***
	(0.070)	(0.073)	(0.072)	(0.093)	(0.095)	(0.094)
Mother's Occupation Syst. (percentiles)	-0.141	-0.025	0.016	-0.221	-0.175	-0.066
	(0.103)	(0.102)	(0.102)	(0.197)	(0.197)	(0.195)
Mother × Father's Occupation Syst. (percentiles)				0.001	0.003	0.001
				(0.003)	(0.003)	(0.003)
Mean Dep. Var. (Percentage Points)	2.1	2.1	2.1	2.1	2.1	2.1
No. of Obs.	564,242	564,242	564,242	564,242	564,242	564,242
Panel C: Diagnosis of Autism Ever						
Father's Occupation Syst.(percentiles)	-0.023	0.032	0.051*	-0.098**	-0.045	-0.020
	(0.030)	(0.031)	(0.031)	(0.041)	(0.041)	(0.042)
Mother's Occupation Syst. (percentiles)	-0.059	-0.027	-0.016	-0.262***	-0.238**	-0.207**
	(0.043)	(0.044)	(0.044)	(0.091)	(0.093)	(0.094)
Mother × Father's Occupation Syst. (percentiles)				0.004**	0.004**	0.003**
				(0.001)	(0.001)	(0.002)
Mean Dep. Var. (Percentage Points)	0.6	0.6	0.6	0.6	0.6	0.6
No. of Obs.	738,126	738,126	738,126	738,126	738,126	738,126

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%. ^Diagnosed with ASD at any age, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same in each column as shown in Table 4.

Table 6. Diagnosis of ASD,
Grandfathers' Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Paternal Grandfather's Occupation Syst.(percentiles)	0.087	0.188***	0.183***	0.270*	0.341**	0.334**
	(0.068)	(0.069)	(0.069)	(0.150)	(0.151)	(0.151)
Maternal Grandfather's Occupation Syst. (percentiles)	-0.076	0.012	0.011	0.105	0.163	0.160
	(0.070)	(0.071)	(0.071)	(0.146)	(0.148)	(0.148)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				-0.004	-0.003	-0.003
				(0.003)	(0.003)	(0.003)
Mean Dep. Var. (Percentage Points)	1.8	1.8	1.8	1.8	1.8	1.8
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
No. of Obs.	420,205	420,205	420,205	420,205	420,205	420,205

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7. Diagnosis of Either ASD or Autism,
Grandfathers' Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by age 8						
Paternal Grandfather's Occ. Syst.(percentiles)	0.141**	0.208***	0.205***	0.188	0.256*	0.250*
	(0.066)	(0.069)	(0.069)	(0.139)	(0.139)	(0.139)
Maternal Grandfather's Occ. Syst.(percentiles)	-0.154**	-0.101	-0.101	-0.107	-0.053	-0.057
	(0.066)	(0.066)	(0.066)	(0.126)	(0.127)	(0.127)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				-0.001	-0.001	-0.001
				(0.002)	(0.002)	(0.002)
Mean Dep. Var. (Percentage Points)	0.9	0.9	0.9	0.9	0.9	0.9
No. of Obs.	288,658	288,658	288,658	288,658	288,658	288,658
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Paternal Grandfather's Occ. Syst.(percentiles)	0.122	0.233**	0.224**	0.389*	0.475**	0.463**
	(0.091)	(0.092)	(0.093)	(0.208)	(0.210)	(0.211)
Maternal Grandfather's Occ. Syst.(percentiles)	-0.122	-0.025	-0.027	0.143	0.214	0.210
	(0.098)	(0.099)	(0.099)	(0.207)	(0.208)	(0.209)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				-0.005	-0.005	-0.005
				(0.004)	(0.004)	(0.004)
Mean Dep. Var. (Percentage Points)	2.1	2.1	2.1	2.1	2.1	2.1
No. of Obs.	288,658	288,658	288,658	288,658	288,658	288,658
Panel C: Diagnosis of Autism Ever						
Paternal Grandfather's Occ. Syst.(percentiles)	0.031	0.059	0.059	-0.026	-0.010	-0.008
	(0.041)	(0.042)	(0.042)	(0.084)	(0.084)	(0.084)
Maternal Grandfather's Occ. Syst.(percentiles)	-0.039	-0.016	-0.016	-0.095	-0.083	-0.082
	(0.038)	(0.039)	(0.039)	(0.079)	(0.080)	(0.080)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				0.001	0.001	0.001
				(0.001)	(0.001)	(0.001)
Mean Dep. Var. (Percentage Points)	0.6	0.6	0.6	0.6	0.6	0.6
No. of Obs.	420,205	420,205	420,205	420,205	420,205	420,205

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ Ever diagnosed with ASD, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same in each column as shown in Table 5.

Table 8. Diagnosis of ASD among Girls,
Field of Parental Education is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Father's Field Syst.	0.145***	0.126***	0.164***	0.137***	0.116***	0.152***
	(0.041)	(0.041)	(0.041)	(0.042)	(0.04195)	(0.041)
Mother's Field Syst.	0.070	0.065	0.066	0.043	0.029	0.024
	(0.065)	(0.065)	(0.065)	(0.081)	(0.082)	(0.082)
Mother × Father's Field Syst.				0.073	0.094	0.11
				(0.132)	(0.132)	(0.133)
Controls for: Child's Gender, Maternal and Paternal Age, Married Mother, Child's Birth Year	X	X	X	X	X	X
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
Mean Dep. Var. (Percentage Points)	0.850	0.850	0.850	0.850	0.850	0.850
No. of Obs.	337,616	337,616	337,616	337,616	337,616	337,616

Estimates are multiplied by 10,000.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9. Diagnosis of ASD among Boys,
Field of Parental Education is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Father's Field Syst.	0.543***	0.487***	0.594***	0.539***	0.480***	0.585***
	(0.076)	(0.076)	(0.076)	(0.081)	(0.081)	(0.080)
Mother's Field Syst.	0.094	0.067	0.074	0.078	0.042	0.042
	(0.100)	(0.102)	(0.102)	(0.121)	(0.125)	(0.126)
Mother × Father's Field Syst.				0.044	0.065	0.083
				(0.220)	(0.224)	(0.226)
Controls for: Child's Gender, Maternal and Paternal Age, Married Mother, Child's Birth Year	X	X	X	X	X	X
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
Mean Dep. Var. (Percentage Points)	2.647	2.647	2.647	2.647	2.647	2.647
No. of Obs.	355,270	355,270	355,270	355,270	355,270	355,270

Estimates are multiplied by 100.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 10. Diagnosis of ASD or Autism among Girls,
Field of Parental Education is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by Age 8						
Father's Field Syst.	0.020	0.027	0.037	0.030	0.034	0.042
	(0.031)	(0.031)	(0.032)	(0.033)	(0.034)	(0.034)
Mother's Field Syst.	0.032	0.041	0.042	0.067	0.066	0.061
	(0.047)	(0.046)	(0.047)	(0.064)	(0.063)	(0.062)
Mother × Father's Field Syst.				-0.091	-0.066	-0.050
				(0.095)	(0.095)	(0.094)
Mean Dep. Var. (Percentage Points)	0.351	0.351	0.351	0.351	0.351	0.351
No. of Obs.	252,782	252,782	252,782	252,782	252,782	252,782
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Father's Field Syst.	0.178***	0.157***	0.203***	0.171***	0.146***	0.189***
	(0.052)	(0.051)	(0.051)	(0.053)	(0.053)	(0.052)
Mother's Field Syst.	0.084	0.073	0.075	0.058	0.034	0.027
	(0.083)	(0.083)	(0.083)	(0.105)	(0.106)	(0.105)
Mother × Father's Field Syst.				0.069	0.104	0.128
				(0.169)	(0.170)	(0.172)
Mean Dep. Var. (Percentage Points)	1.016	1.016	1.016	1.016	1.016	1.016
No. of Obs.	252,782	252,782	252,782	252,782	252,782	252,782
Panel C: Diagnosis of Autism Ever						
Father's Field Syst.	0.010	0.012	0.029	0.007	0.008	0.025
	(0.023)	(0.023)	(0.023)	(0.024)	(0.025)	(0.025)
Mother's Field Syst.	0.021	0.023	0.023	0.011	0.011	0.010
	(0.033)	(0.033)	(0.034)	(0.039)	(0.038)	(0.038)
Mother × Father's Field Syst.				0.027	0.031	0.034
				(0.070)	(0.069)	(0.070)
Mean Dep. Var. (Percentage Points)	0.229	0.229	0.229	0.229	0.229	0.229
No. of Obs.	337,616	337,616	337,616	337,616	337,616	337,616

Estimates are multiplied by 100. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ Diagnosed with ASD at any age, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same for each column as shown in Table 2.

Table 11. Diagnosis of ASD or Autism among Boys,
Field of Parental Education is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by Age 8						
Father's Field Syst.	0.332***	0.298***	0.355***	0.342***	0.307***	0.362***
	(0.066)	(0.067)	(0.069)	(0.070)	(0.071)	(0.073)
Mother's Field Syst.	0.004	-0.003	0.000	0.040	0.028	0.024
	(0.089)	(0.089)	(0.089)	(0.109)	(0.109)	(0.110)
Mother × Father's Field Syst.				-0.097	-0.082	-0.062
				(0.191)	(0.195)	(0.198)
Mean Dep. Var. (Percentage Points)	1.490	1.490	1.490	1.490	1.490	1.490
No. of Obs.	265,684	265,684	265,684	265,684	265,684	265,684
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Father's Field Syst.	0.644***	0.574***	0.714***	0.643***	0.571***	0.707***
	(0.096)	(0.097)	(0.096)	(0.102)	(0.103)	(0.101)
Mother's Field Syst.	0.062	0.017	0.031	0.057	0.005	0.009
	(0.122)	(0.124)	(0.124)	(0.149)	(0.152)	(0.153)
Mother × Father's Field Syst.				0.013	0.030	0.059
				(0.275)	(0.280)	(0.283)
Mean Dep. Var. (Percentage Points)	3.133	3.133	3.133	3.133	3.133	3.133
No. of Obs.	265,684	265,684	265,684	265,684	265,684	265,684
Panel C: Diagnosis of Autism Ever						
Father's Field Syst.	0.145***	0.139***	0.169***	0.146***	0.139***	0.169***
	(0.042)	(0.042)	(0.041)	(0.047)	(0.046)	(0.046)
Mother's Field Syst.	0.022	0.017	0.019	0.027	0.018	0.019
	(0.057)	(0.058)	(0.058)	(0.068)	(0.069)	(0.069)
Mother × Father's Field Syst.				-0.014	-0.004	0.001
				(0.127)	(0.126)	(0.127)
Mean Dep. Var. (Percentage Points)	0.878	0.878	0.878	0.878	0.878	0.878
No. of Obs.	355,270	355,270	355,270	355,270	355,270	355,270

Estimates are multiplied by 100. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ Diagnosed with ASD at any age, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same for each column as shown in Table 2.

Table 12. Diagnosis of ASD among Girls,
Parental Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Father's Occupation Syst.(percentiles)	0.011	0.108*	0.144**	0.025	0.102	0.151**
	(0.057)	(0.060)	(0.061)	(0.073)	(0.074)	(0.074)
Mother's Occupation Syst. (percentiles)	-0.046	0.009	0.024	-0.008	-0.005	0.042
	(0.081)	(0.080)	(0.080)	(0.164)	(0.163)	(0.163)
Mother × Father's Occupation Syst. (percentiles)				-0.001	0.000	-0.000
				(0.003)	(0.003)	(0.003)
Mean Dep. Var. (Percentage Points)	0.850	0.850	0.850	0.850	0.850	0.850
Controls for: Child's Gender, Maternal and Paternal Age, Married Mother, Child's Birth Year	X	X	X	X	X	X
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
No. of Obs.	359,398	359,398	359,398	359,398	359,398	359,398

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 13. Diagnosis of ASD among Boys,
Parental Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Father's Occupation Syst.(percentiles)	0.046	0.325***	0.408***	-0.065	0.192	0.303**
	(0.093)	(0.093)	(0.093)	(0.127)	(0.128)	(0.130)
Mother's Occupation Syst. (percentiles)	-0.212	-0.082	-0.028	-0.512*	-0.442	-0.309
	(0.140)	(0.141)	(0.141)	(0.272)	(0.271)	(0.272)
Mother × Father's Occupation Syst. (percentiles)				0.005	0.006	0.005
				(0.004)	(0.004)	(0.004)
Mean Dep. Var. (Percentage Points)	2.647	2.647	2.647	2.647	2.647	2.647
Controls for: Child's Gender, Maternal and Paternal Age, Married Mother, Child's Birth Year	X	X	X	X	X	X
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
No. of Obs.	378,728	378,728	378,728	378,728	378,728	378,728

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 14. Diagnosis of ASD or Autism among Girls,
Parental Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by Age 8						
Father's Occupation Syst.(percentiles)	-0.021	0.038	0.050	-0.001	0.054	0.072
	(0.042)	(0.043)	(0.043)	(0.056)	(0.055)	(0.056)
Mother's Occupation Syst. (percentiles)	-0.004	0.033	0.037	0.049	0.077	0.096
	(0.056)	(0.057)	(0.057)	(0.144)	(0.143)	(0.144)
Mother × Father Occupation Syst. (percentiles)				-0.001	-0.001	-0.001
				(0.002)	(0.002)	(0.002)
Mean Dep. Var. (Percentage Points)	0.351	0.351	0.351	0.351	0.351	0.351
No. of Obs.	274,711	274,711	274,711	274,711	274,711	274,711
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Father's Occupation Syst.(percentiles)	0.028	0.137*	0.174**	0.055	0.143	0.192**
	(0.072)	(0.076)	(0.077)	(0.093)	(0.093)	(0.094)
Mother's Occupation Syst. (percentiles)	-0.074	0.007	0.022	-0.003	0.022	0.069
	(0.099)	(0.099)	(0.099)	(0.206)	(0.204)	(0.203)
Mother × Father's Occupation Syst. (percentiles)				-0.001	-0.000	-0.001
				(0.003)	(0.003)	(0.003)
Mean Dep. Var. (Percentage Points)	1.016	1.016	1.016	1.016	1.016	1.016
No. of Obs.	274,711	274,711	274,711	274,711	274,711	274,711
Panel C: Diagnosis of Autism Ever						
Father's Occupation Syst.(percentiles)	-0.008	0.014	0.028	-0.003	0.017	0.038
	(0.028)	(0.029)	(0.029)	(0.037)	(0.038)	(0.039)
Mother's Occupation Syst. (percentiles)	0.030	0.039	0.044	0.044	0.047	0.071
	(0.044)	(0.044)	(0.044)	(0.085)	(0.086)	(0.086)
Mother × Father's Occupation Syst. (percentiles)				-0.000	-0.000	-0.000
				(0.001)	(0.001)	(0.001)
Mean Dep. Var. (Percentage Points)	0.229	0.229	0.229	0.229	0.229	0.229
No. of Obs.	359,398	359,398	359,398	359,398	359,398	359,398

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%. ^Diagnosed with ASD at any age, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same in each column as shown in Table 4.

Table 15. Diagnosis of ASD or Autism among Boys,
Parental Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by Age 8						
Father's Occupation Syst.(percentiles)	-0.007	0.203**	0.254***	-0.018	0.184	0.253**
	(0.086)	(0.086)	(0.087)	(0.115)	(0.114)	(0.117)
Mother's Occupation Syst. (percentiles)	-0.168	-0.080	-0.058	-0.199	-0.131	-0.061
	(0.118)	(0.121)	(0.121)	(0.227)	(0.226)	(0.227)
Mother × Father Occupation Syst. (percentiles)				0.001	0.001	0.000
				(0.003)	(0.003)	(0.003)
Mean Dep. Var. (Percentage Points)	1.490	1.490	1.490	1.490	1.490	1.490
No. of Obs.	289,531	289,531	289,531	289,531	289,531	289,531
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Father's Occupation Syst.(percentiles)	0.076	0.396***	0.496***	-0.006	0.285*	0.424***
	(0.119)	(0.119)	(0.118)	(0.160)	(0.161)	(0.161)
Mother's Occupation Syst. (percentiles)	-0.211	-0.063	0.001	-0.431	-0.362	-0.193
	(0.169)	(0.171)	(0.171)	(0.345)	(0.346)	(0.346)
Mother × Father's Occupation Syst. (percentiles)				0.004	0.005	0.003
				(0.005)	(0.005)	(0.005)
Mean Dep. Var. (Percentage Points)	3.133	3.133	3.133	3.133	3.133	3.133
No. of Obs.	289,531	289,531	289,531	289,531	289,531	289,531
Panel C: Diagnosis of Autism Ever						
Father's Occupation Syst.(percentiles)	-0.036	0.048	0.072	-0.187**	-0.106	-0.076
	(0.053)	(0.053)	(0.054)	(0.073)	(0.074)	(0.077)
Mother's Occupation Syst. (percentiles)	-0.145**	-0.096	-0.079	-0.553***	-0.513***	-0.476***
	(0.071)	(0.073)	(0.073)	(0.161)	(0.163)	(0.165)
Mother × Father's Occupation Syst. (percentiles)				0.007***	0.007***	0.007**
				(0.003)	(0.003)	(0.003)
Mean Dep. Var. (Percentage Points)	0.878	0.878	0.878	0.878	0.878	0.878
No. of Obs.	378,728	378,728	378,728	378,728	378,728	378,728

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%. ^Diagnosed with ASD at any age, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same in each column as shown in Table 4.

Table 16. Diagnosis of ASD among Girls,
Grandfather' Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Paternal Grandfather's Occupation Syst.(percentiles)	0.022	0.069	0.069	0.061	0.082	0.081
	(0.065)	(0.066)	(0.066)	(0.144)	(0.146)	(0.146)
Maternal Grandfather's Occupation Syst. (percentiles)	0.016	0.070	0.072	0.055	0.083	0.084
	(0.074)	(0.076)	(0.076)	(0.142)	(0.145)	(0.145)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				-0.001	-0.000	-0.000
				(0.003)	(0.003)	(0.003)
Mean Dep. Var. (Percentage Points)	0.850	0.850	0.850	0.850	0.850	0.850
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
No. of Obs.	204,734	204,734	204,734	204,734	204,734	204,734

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 17. Diagnosis of ASD among Boys,
Grandfathers' Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Paternal Grandfather's Occupation Syst.(percentiles)	0.138	0.299***	0.292***	0.453*	0.602**	0.594**
	(0.111)	(0.113)	(0.113)	(0.262)	(0.266)	(0.266)
Maternal Grandfather's Occupation Syst. (percentiles)	-0.171	-0.024	-0.029	0.141	0.277	0.271
	(0.123)	(0.123)	(0.124)	(0.247)	(0.249)	(0.249)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				-0.006	-0.006	-0.006
				(0.005)	(0.005)	(0.005)
Mean Dep. Var. (Percentage Points)	2.647	2.647	2.647	2.647	2.647	2.647
Mother and Father's Level of Education	X	X		X	X	
Full Interactions of Mother and Father's Level of Education			X			X
Father's Income at Age 35			X			X
Child's Location of Birth FE		X	X		X	X
No. of Obs.	215,471	215,471	215,471	215,471	215,471	215,471

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 18. Diagnosis of ASD or Autism among Girls,
Grandfathers' Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by Age 8						
Paternal Grandfather's Occ. Syst.(percentiles)	0.044	0.064	0.063	-0.027	-0.019	-0.020
	(0.060)	(0.061)	(0.061)	(0.136)	(0.134)	(0.134)
Maternal Grandfather's Occ. Syst.(percentiles)	-0.098*	-0.070	-0.071	-0.168	-0.152	-0.152
	(0.058)	(0.059)	(0.059)	(0.125)	(0.124)	(0.124)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				0.001	0.002	0.002
				(0.002)	(0.002)	(0.002)
Mean Dep. Var. (Percentage Points)	0.351	0.351	0.351	0.351	0.351	0.351
No. of Obs.	140,631	140,631	140,631	140,631	140,631	140,631
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Paternal Grandfather's Occ. Syst.(percentiles)	-0.005	0.046	0.046	-0.085	-0.071	-0.076
	(0.088)	(0.091)	(0.090)	(0.199)	(0.202)	(0.202)
Maternal Grandfather's Occ. Syst.(percentiles)	0.000	0.071	0.072	-0.079	-0.045	-0.048
	(0.102)	(0.107)	(0.107)	(0.199)	(0.205)	(0.204)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				0.002	0.002	0.002
				(0.003)	(0.004)	(0.004)
Mean Dep. Var. (Percentage Points)	1.016	1.016	1.016	1.016	1.016	1.016
No. of Obs.	140,631	140,631	140,631	140,631	140,631	140,631
Panel C: Diagnosis of Autism Ever						
Paternal Grandfather's Occ. Syst.(percentiles)	0.031	0.035	0.035	-0.076	-0.072	-0.070
	(0.039)	(0.039)	(0.039)	(0.079)	(0.079)	(0.079)
Maternal Grandfather's Occ. Syst.(percentiles)	-0.030	-0.020	-0.020	-0.135*	-0.126	-0.124
	(0.041)	(0.042)	(0.042)	(0.076)	(0.077)	(0.077)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				0.002	0.002	0.002
				(0.001)	(0.001)	(0.001)
Mean Dep. Var. (Percentage Points)	0.229	0.229	0.229	0.229	0.229	0.229
No. of Obs.	204,734	204,734	204,734	204,734	204,734	204,734

Estimates are multiplied by 10,000. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ Ever diagnosed with ASD, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same in each column as shown in Table 5.

Table 19 Diagnosis of ASD or Autism among Boys, Grandfathers' Occupation is the Basis of the Systemizing Measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Diagnosis of ASD by Age 8						
Paternal Grandfather's Occ. Syst.(percentiles)	0.233**	0.321***	0.317***	0.394*	0.543**	0.537**
	(0.113)	(0.117)	(0.118)	(0.239)	(0.242)	(0.241)
Maternal Grandfather's Occ. Syst.(percentiles)	-0.213*	-0.138	-0.141	-0.053	0.082	0.077
	(0.119)	(0.118)	(0.118)	(0.227)	(0.230)	(0.230)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				-0.003	-0.004	-0.004
				(0.004)	(0.004)	(0.004)
Mean Dep. Var. (Percentage Points)	1.490	1.490	1.490	1.490	1.490	1.490
No. of Obs.	148,027	148,027	148,027	148,027	148,027	148,027
Panel B: Diagnosis of ASD on the "Age 8" sample^						
Paternal Grandfather's Occ. Syst.(percentiles)	0.239	0.392**	0.377**	0.833**	1.005***	0.997***
	(0.149)	(0.152)	(0.152)	(0.364)	(0.368)	(0.368)
Maternal Grandfather's Occ. Syst.(percentiles)	-0.247	-0.094	-0.103	0.342	0.514	0.511
	(0.173)	(0.173)	(0.174)	(0.348)	(0.352)	(0.351)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				-0.012*	-0.012*	-0.012*
				(0.006)	(0.006)	(0.006)
Mean Dep. Var. (Percentage Points)	3.133	3.133	3.133	3.133	3.133	3.133
No. of Obs.	148,027	148,027	148,027	148,027	148,027	148,027
Panel C: Diagnosis of Autism Ever						
Paternal Grandfather's Occ. Syst.(percentiles)	0.030	0.075	0.076	0.021	0.056	0.058
	(0.064)	(0.065)	(0.065)	(0.138)	(0.140)	(0.140)
Maternal Grandfather's Occ. Syst.(percentiles)	-0.048	-0.011	-0.012	-0.057	-0.029	-0.029
	(0.068)	(0.068)	(0.068)	(0.139)	(0.140)	(0.140)
Paternal × Maternal Grandfathers' Occupation Syst. (percentiles)				0.000	0.000	0.000
Mean Dep. Var. (Percentage Points)	0.878	0.878	0.878	0.878	0.878	0.878
No. of Obs.	215,471	215,471	215,471	215,471	215,471	215,471

Estimates are multiplied by 100. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ Ever diagnosed with ASD, but restricted to the 1995 – 2006 birth cohorts. Control sets are the same in each column as shown in Table 5.