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GENDER BASED OCCUPATIONAL SEGREGATION AND SEX DIFFERENCES IN SENSORY, MOTOR AND SPATIAL APTITUDES

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ABSTRACT

While the gender pay gap continues to decline, gender occupational segregation in the labor market has changed little in recent decades. Research on sex differences in humans provides "lab evidence" of gender differences in sensory, motor and spatial aptitudes. We provide evidence that these skills, as captured by DOT codes, strongly predict the occupational choices of men and women, in the directions indicated by this research. We estimate that if selection on these skills were eliminated, the Duncan index of gender based occupational segregation would be roughly 23 percent lower than its actual level, in both 1970 and 2012. In recent years, occupational selection on these aptitudes works, on average, to lower the gender earnings gap.

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The male/female gap in labor market compensation has declined significantly over the past three decades in many developed countries. In the U.S., the female/male ratio of median annual earnings for full time workers has increased from 0.62 in 1979 to 0.83 in 2014 (BLS 2015). In countries that measure the gender gap in hourly earnings the female/male ratio is even higher—for example, in 2014 it was 0.88 in Canada (CANSIM) and in 2015 it was 0.91 in the UK (Office for National Statistics 2015). In comparison, the pace of change in the gender segregation of employment in recent decades has been glacial. Blau et al. (2013) report that while the Duncan index[1] of gender occupational segregation declined by over 10 points in the 1970s and 1980s, it declined by just over 3 points in the following two decades. Furthermore, the index tells us that the overall segregation of males and females remains substantial: in recent years over half of men (or women) would need to change occupations for the occupational distributions of male and female employment to be the same.

The persistence of gender segregation in employment presents a puzzle. Women now enter the labor market with higher average levels of education than males and many explicit barriers to their entry to certain occupations have been removed. It is important to understand why this segregation persists, as it may explain part of the remaining gap between male and female compensation. For example, Blau and Kahn (2006) show that occupational choice accounted for one-fifth of the decline in the US earnings gap in the 1980's, while Goldin (2014) reports that roughly one-third of the current gender earnings gap is attributable to wage variation across occupations. Also, the segregation of the

[1] The Duncan index, which is defined below, ranges between 0 and 1 and is interpreted to indicate the proportion of women or men who would need to change occupations to produce a similar occupational distribution of men and women.

genders across occupations of the labor market implies that the sectoral change that accompanies economic growth is likely to have important effects on the relative compensation of men and women. Finally, if occupational segregation is an object of policy interest, an effective response must be rooted in an understanding of its sources.

There are differences in the circumstances that men and women face that could explain the persistence of occupational segregation. First, there are gender-specific costs to entering particular occupations because of social expectations and rules. Historically, these included explicit discrimination: women were barred admission to certain fields of employment, or from the training and education to enter those fields. While explicit discrimination may play a smaller role today, social perceptions about gender may still be an important determinant of occupational segregation.[2] Second, men and women may have different demands for job characteristics. In particular, women may have a preference for occupations in which the terms of employment accommodate their greater family responsibilities. For example, Goldin (2014) argues this could manifest as a preference for occupations in which the hours/reward locus is linear.

Men and women may also choose different professions because they enter the labor market with different aptitudes and skills. Initial skill endowments affect occupation choice because lifetime earnings depend upon finding the right match between one's aptitudes and job requirements. Sex differences have been documented across a wide range of aptitudes and skills that may be relevant for labor market decisions. In some cases, the origin of these differences is thought to be genetic (for example, differences in the incidence of color blindness); for other skill differences, such

[2] For example, a number of papers argue that men prefer jobs that are predominantly male for reasons of prestige and social comfort, and tend to abandon occupations rapidly once they “tip” to being predominantly female (Akerlof and Kranton 2000, Golden 2013, Pan 2015).

as men and women's different interpersonal strengths,[3] environmental factors may play a significant role. Regardless of their origin, sex differences in aptitudes that are evident by early adulthood seem a likely candidate to influence labor market decisions.

Research in fields other than economics has investigated gender differences in a wide variety aptitudes and skills. Part of this effort is to discover whether any gender differences are biological or acquired. In economics, a small literature has examined gender differences in some of these skills in an attempt to understand the impact of technological change on male and female wages (e.g. Weinberg 2000; Black and Spitz-Oener 2011; Borghans et al. 2014.) To our knowledge, however, there has been no comprehensive attempt to link the scientific literature on sex differences in many of these aptitudes with the observed degree of occupational segregation.

This paper assesses the potential for sex differences in the sensory, motor and spatial attributes of occupations, as captured by Dictionary of Occupational Titles (DOT) codes, to account for sex segregation across occupations. We use data on job skill requirements taken from the DOT rating system to provide evidence on the skill profiles of jobs chosen by men and women, and how these have changed over time.

We begin by reviewing the research in other fields on gender differences in these characteristics. In our review, we summarize the current understanding of the possible sources of any sex differences and, where possible, document the ages at which the difference emerges. While our conclusions about the potential importance of skills accounting for labor market segregation do not depend on knowing anything about the origin of skill differences, this knowledge is important for formulating effective policies

[3] Borghans et al. (2014) examine how differences in interpersonal style affect the relative wages of men and women.

to address segregation.

In the following section, we revisit the existing evidence of segregation in the US labor market over the past five decades. We confirm previous research showing that after a period of desegregation in the 1970's and 80s, the Duncan index has been "stuck" at just over 0.5 for the last 20 years. We also show that the occupations that make the largest contributions to aggregate segregation have not changed significantly over this period. Notably, none of these occupations are part of the STEM group of jobs that have been the focus of a great deal of recent research on gender and occupational choice. STEM occupations (while of interest for other reasons) do not make a significant contribution to gender occupational segregation. If there were equal representation of males and females in all STEM occupations in 2012 the Duncan index would be 0.493, a decline of about 2.6 percent from its actual level of 0.506. In contrast, equal representation in the five occupations that contribute most to the Duncan index would result in a decline that is nearly four times as large.

We next map the evidence of sex differences in sensory, motor and spatial aptitudes into DOT occupational codes, and then relate these codes to different patterns of job selection by men and women. Specifically, we regress the log odds of male to female employment in an occupation on our DOT aptitude measures. Research in other disciplines documents gender differences in aptitudes comparable to our DOT measures through laboratory testing. With few exceptions gender differences in the occupational attributes line up with the results of this research, suggesting that the "lab" evidence has some implications for economic life.

To summarize our findings we construct estimates of the Duncan index of gender occupational segregation net of any association between occupational choice and these DOT attributes. The results show that if the association between our skill measures and selection into occupations was similar for men and women, the Duncan index in 2012 would be significantly lower: 0.382, as opposed to 0.508 observed in the data.[4]

Of course, it is possible that the occupational skill differences we investigate are correlated with other features of occupations that explain differential selection by men and women. We do investigate a variety of specifications that control for some of these features. However, the primary significance of the skill differences we document is their precedence in other scientific literatures on gender differences. Our analysis simply tells us how strongly men and women's choices are correlated with these documented gender differences and so provides guidance for future research. It should also inform the research on sex differences in these other fields. In many instances, sex differences are measured using standardized tests or laboratory observation at young ages. The lived experience of any sex differences measured this way, however, is largely unknown and therefore a matter of speculation.

Finally, we examine the potential implications of gender selection on these aptitudes for the occupational wage gap. We show that eliminating the selection on these skills results in a *higher* gender wage gap, as a result of an increase in the cross-occupational component. This is because there are several high-paying occupations in which selection on these skills favors women (in particular, nurses, physicians and accountants). Increases in the across occupation term from these jobs are sufficiently large that they are not offset by declines across the majority of other occupations.

[4] The Duncan index for all 501 2000 Census occupation codes is 0.506. For the 476 jobs that we are able to link to DOT codes in both 1970 and 2012, the Duncan index is 0.508.

Previous Literature

Our investigation is related to at least two strands of economic research. The first strand provides evidence on the gender segregation of occupations. The separation of the genders across occupations is a long standing feature of the labor market (e.g., Blau Weiskoff 1972, Blau et al 2013 and the overview in Blau and Kahn 2000). It has generated related investigations into the relative pay of male and female jobs (e.g., MacPherson and Hirsch 1995) and into the sources of segregation. Economic theories of segregation have focused on employer or coworker discrimination (e.g., Becker 1957) or the self-selection of males and females into different occupations. This selection is thought to occur on the basis of occupational skill requirements, rates of skill depreciation interacting with gender differences in expected lifetime labor market participation (e.g., Polachek 1981), or in response to gender differences in the relative demands of market and non market activities (e.g., Becker 1985).[5]

The second strand is research on the task content of jobs. Viewing jobs as a bundle of tasks or required skills has shed light on the impact of technological change on the distribution of employment and relative rates of pay (Autor et al. 2003, Acemoglu and Autor 2011, Weinberger 2014). As noted above, this approach has more recently been used to understand differences in trends in female and male employment and wages (Autor and Price 2013, Black and Spitz-Oener 2011, Borghans et al. 2014), emphasizing the gender differences in the impact of new technologies and the changing demand for people skills and physical brawn.

A concern in task research is that the definitions of task groups in use are not

[5] Still another theory focuses on the undervaluation of "women's work" due to discrimination but does not provide an explicit explanation of why gender segregation arises in the first place.

necessarily distinct and many are open to debate (e.g., Autor 2013). While the task constructs that we propose will not be useful for all purposes, they are based on research in other fields on gender differences in skills and abilities.

Finally, there is also a strand of research in sociology that has investigated the relationship between occupational gender segregation and occupational skills. For example, Bielby and Baron (1986) investigate the relationship between occupational segregation in a sample of firms in California in the 1960s and 70s and DOT skill measures. The basis for the hypothesized skill differences across genders is a contemporaneous summary of research on sex differences, primarily from psychology (Maccoby and Jacklin 1974). They conclude that neither the skills examined nor measures of turnover costs can account for the observed segregation. More recently Levanon and Grusky (2012) examine gender occupational segregation and a more comprehensive array of skill measures taken from the Occupational Information Network (O*NET) database. They conclude that physical and interactional social skills are particularly important. This research is complementary to economic research emphasizing males' physical/strength abilities and females' people skills.

Against this background, the contribution of this paper is to examine the importance of a broader and different range of skill differences than have been addressed in the economics literature to date, and to attempt to explain occupational segregation (in an accounting sense) with respect to these measures.

Gender Differences in the Skills and Abilities

Investigation of gender differences in skills and abilities is very active in many fields. This research has spawned popular debate through books that both support and condemn a biological interpretation of the differences between males and females (e.g., Brizendine 2007, Fine 2010; McCarthy and Ball 2011).

Explanations of gender differences fall into three general classes. The leading biological explanation, which is currently the focus of research in many fields, is prenatal exposure to hormones, and in particular androgens (see, for example Halpern 2012). Males have greater prenatal exposure to androgens, most significantly testosterone, and have higher levels of circulating testosterone post birth. The higher prenatal and postnatal exposure to androgens is hypothesized to have organizational impacts on the developing brain. For example, it is thought to lead to right brain dominance in males, endowing males with an "advantage" in functions and abilities controlled by the right hemisphere—for example the higher incidence of left handedness among males—as well as accentuating functions that are controlled by parts of the brain that have relatively high numbers of androgen receptors. Conversely, females have advantage in functions and abilities controlled by the left hemisphere—for example, verbal skills.

Evidence in favor of these theories is constructed by relating levels of prenatal androgens—measured either directly or by markers such as the ratio of the lengths of the second digit to the fourth digit of the hand (the 2D:4D ratio)—to specific skills. There are also investigations of the relative abilities of children who are exposed to greater levels of prenatal androgens than the norm—for example different sex dizygotic twins and children with congenital adrenal hyperplasia (CAH)—and variation in abilities according to natural or synthetic variation in hormones (e.g., menstrual cycles and hormone replacement therapy). Other supporting evidence comes from studies of non-human mammals.

A second class of explanations is founded on evolutionary principles of natural selection and the traditional gender roles in hunter/gatherer societies. The hypothesis is that natural selection has favoured the reproduction of males with “hunting skills” and females with “gathering skills”. The support for this explanation is through an interpretation of gender differences in skills through this lens. For example, a male advantage in targeting distant objects reflects a hunter past, while a female advantage in fine motor skills echoes a foraging background.

The third class of explanations is that any gender differences are environmentally determined. Girls and boys are viewed as equally endowed, but they are subsequently subjected to different circumstances as a result of cultural norms and/or differential access to power. For example, males’ affinity for things and females’ affinity for people might be traced through a lifetime of dichotomous stimuli, perhaps starting with the truck/doll divide in childhood. Unfortunately, simple documentation of gender differences in these environments does not provide much leverage to test this explanation. For example, Dickens and Flynn (2001) argue genes and environment are matched in ways to amplify what might initially be a modest genetic based difference. Absent controlled experiments, the primary leverage to test the environmental explanation is to discover whether gender differences in traits are present at very young ages before the effects of social environments can have much effect.

While not strictly speaking an explanation, it is also important to note that another participant in this debate is an argument that the evidence does not support any gender differences in traits. The "gender similarities hypothesis", associated with Hyde (2005), maintains that based on meta analyses most effect sizes—the standardized difference in means—of male/female differences are either close to zero or small (in general less than 0.35).[6]

At present there is no clear winner among these opposing views. Currently biological explanations attract much of the research and much of the controversy. Our analysis does not shine any new light on the origins of sex differences in skills and aptitudes. For our purposes the more important consideration is whether any differences are present before occupational choices are made so they are not the result of learned occupational experience. The debate about the origins of sex differences is relevant, of course, to the formulation of policies designed to address any differential selection into occupations on the basis of skills.

Finally, much of the criticism of the use of research on sex differences to explain everyday life is rooted in speculation of what the differences might mean versus speculation that effect sizes of certain magnitudes must not mean anything. We instead ask the empirical question of how occupational selection lines up with the researched sex differences, conditional on our mapping of the sex differences into DOT codes.

Gender Differences in Sensory Functions

Gender differences in some sensory functions have long been reported (Velle 1987). Certain differences have an explicit genetic origin, such as colour blindness. For others the exact source is still under investigation, although they are well documented

[6] Our focus is on sensory, motor and visiospatial gender differences that are mostly not covered in Hyde's evidence and/or are more generally regarded as areas in which gender differences do exist.

(see also Halpern 2012, 105-107 for an overview).

Vision—One dimension of gender differences in vision has a clear genetic source. The incidence of colour blindness is much higher in males than in females because the most prevalent forms (red/green) are a result of gene deletion or damage on the X chromosome. Because females have two X chromosomes and males have one, and color blindness is a recessive trait, this consequence of genetic abnormalities of this chromosome is more likely to be inherited by males.

While there is a large gender difference in the incidence of color blindness, the overall incidence is small enough that color blind individuals may be easily able to match with jobs that do not require color discrimination skills. Recent research, however, suggests that, within a sample of college students, females exhibit greater sensitivity to colour than males in populations with normal vision (Handa and McGivern 2015; Abramov et al. 2012b, Murray et al. 2012), while in a sample of 16-23 month old infants a higher proportion of females could distinguish colours (Mercer et al. 2014).

Research into gender differences in vision other than color blindness is relatively recent, and a proposed explanation is males' higher levels of androgen exposure. For example, adult males exhibit better visual acuity—sensitivity to fine detail and rapidly moving stimuli (Velle 1987, Abramov et al. 2012a). A suspected cause is the high number of testosterone receptors in the cerebral cortex. Environmental factors may also play a role, as there is evidence that vision acuity can be improved through training (Ward et al. 2008; also see Halpern, 2012). Finally, evolutionary explanations have also been forwarded based on the distinct gender roles in hunter/gatherer societies (Abramov et al. 2012a).

This same evolutionary hypothesis has led researchers to look for sex differences in the visual perception of near and far space. Recent research has provided evidence of the better accuracy of females in near space and of males in far space in a sample of young adults (Stancy and Turner 2010), and similar gender differences in puzzle solving (Sanders et al. 2007b).

Hearing—Females have been observed to have a higher degree of auditory sensitivity than males (detecting weak sounds in quiet), especially at higher frequencies, starting in childhood (Halpern 2012, McFadden 1998, Velle 1987). Conversely, males have been observed to have a higher tolerance of noise, again starting in childhood (Velle 1987). Roughly speaking females have been found to experience a given noise level twice as strongly as males. Males are observed to have better abilities in sound localization, have a larger right ear advantage and better at distinguish signal sounds through masking sounds (McFadden 1998).

Among older populations environmental factors are thought to contribute to these sex differences in hearing. However, the environment is less likely to be a factor for differences found among children. One branch of current research is on the impact of androgens on the development of auditory function. For example, the higher exposure of males to androgens in the prenatal period is thought to weaken cochlear amplifiers. For example, males have weaker otoacoustic emissions than females, even at very young ages (McFadden 2002, McFadden 2008, Halpern 2012).

Taste and Smell—Females have been observed to have a better sense of smell and taste. The documentation of sex differences in the sense of smell has a long history and is widely believed (see Brand and Millot 2001 for a survey). While sex differences have not been observed for the sensitivity to, or ability to, discriminate all smells, where they are detected they always indicate greater ability for females—Halpern (2012, p.106) reports that the advantage "extends across the entire lifespan". Environmental explanations have been offered for these differences—females may have a larger learned experience with odours. However, evidence of sex differences at early ages and female superiority at identifying "male" odours suggests there are other factors at play. Candidates for explaining this difference are sex differences in anatomy, brain structure and/or function, evolutionary functions and gender differences in verbal ability. The evidence on sex differences in taste recognition and perception are more mixed suggesting females perceive some tastes better, but others not as well (Halpern 2012 107).

Touch—Finally, females have been observed to have a better sense of touch, a finding for both blind and sighted subjects so distinct from sex differences in visual acuity (Halpern 2012). At least one dimension of this difference appears to be biological. Perception of textures is related to the density of sense perceptors—Merkel cells—in the hand. Smaller hands have a higher density of these cells. Therefore female's smaller stature and smaller finger size, on average, leads to their better perception of textures (Peters et al. 2009). Touch sensitivity has been found to be similar between men and women with similar finger size.

Gender Differences in Perceptual Motor Tasks

Motor Abilities—There is evidence of sex differences in some motor and visual coordination tasks. Tests of abilities for aiming at moving or stationary targets appear to favour males by a relatively large margin (Hall and Kimura 1995, Watson and Kimura

1991, but also see Auyeung et al 2011), while females demonstrate an advantage in fine motor dexterity (Nicholson and Kimura 1996). Tests of both these abilities find similar sex differences among young children (Sanders and Kadam 2001).

Common tests of these abilities have been criticised for conflating any sex differences in perceptions of near and far space with any sex differences in specific motor skills. Controlling for sex differences in space, Sanders et al. (2007a) present evidence that females perform better in finger tasks while males perform better in arm tasks.

Recent research takes up this distinction between a gross motor movement advantage for males and a fine motor movement advantage for females (see Sanders 2013 for an overview). For example, females have an advantage in movements of the wrist and fingers (Sanders and Walsh 2007, Sanders and Perez 2007). Finally, a male advantage has also been observed for tests of reaction time and finger tapping (Roivainen 2011).

The origins of these differences have not been isolated but evolutionary and (because this skill can improve with practice) environmental sources are possibilities. Prenatal testosterone exposure may also play a role as the 2D:4D digit ratio appears to predict targeting performance (Falter et al. 2006). Sanders (2013) cites recent evidence that hand and arm muscle manipulation are controlled by the brain's primary motor cortex via different "tracts" and there is recent evidence of sex differences in the regions of the brain associated with motor control.

Perceptual Motor Tasks—Sex differences in some perceptual motor tasks, especially those involving digits and alphabets, appear to favour females (e.g., Roivainen 2011). These include perceptual speed, fine motor manipulations and tactile skills. For example, females have an advantage in the "Digit Symbol" task (formerly part of the Wechsler Scales) but not the "Inspection Time" task (Halpern 2012, Burns and Nettelbeck 2005). A female advantage in the Processing Speed Index of the Wechsler scales has been reliably found in a sample of primary and secondary school aged children (Longman et al. 2007).

Some of these differences are again attributed to females' smaller stature, on average—females' smaller hand size on average might contribute to their advantage in fine motor tasks (Peters et al. 1990 and Peters and Compagnaro 1996).

Gender Differences in Visiospatial Abilities

Sex differences in visiospatial abilities have been widely documented and in general favour males. The advantage is not uniform, however. Halpern (2012) in her review reports a male advantage in spatial perception, mental rotation, spatiotemporal ability, and to a lesser extent, spatial visualization. The evidence for abilities related to the generation and maintenance of a spatial image are mixed. Females have an advantage in remembering the spatial location of objects in an array (Sanders 2013). There is evidence that the gender difference in some of these abilities emerges at very young ages (e.g., Moore and Johnson 2008, Quinn and Liben 2008).

Recent research emphasizes that in summarising this literature it is important to consider variation in the difficulty of the skill test across studies and the possible conflation of different skills within a single test. For example, Sanders (2013) argues that the evidence indicates a strong male advantage in coincidence-anticipation timing (CAT—for example, the ability to predict when a projectile weapon will reach a moving target), in children and adults, predominately in easier rather than harder CAT tasks. CAT skills are useful for activities such as sports and driving. Also, as noted above common tests of targeting and motor abilities potentially conflate sex differences in motor functions and sex differences in perceptions of near and far space. Sanders (2013) reports that there is good evidence of a male advantage in the processing of far space and a female advantage in the processing of near space, although there are also some anomalous studies.

An androgen based explanation of male advantage in visual spatial skills has been forwarded, based on evidence that these abilities are related to the 2D:4D ratio and that many visual spatial functions are controlled by the right hemisphere of the brain (e.g., Collaer et al. 2007, Peters et al. 2007). Sanders (2013) notes that near and far space are processed by different mechanisms in the brain, setting the stage for sex differences in the development of these mechanisms to be important. However, there is also evidence that measures of the gender difference in spatial abilities vary across countries according to some measures of socio-economic development, although not always in expected ways (e.g., Lippa et al. 2008). In addition, there is evidence that mastery of spatial skills is responsive to training (e.g., Miller and Halpern 2013, Hyde 2014). Finally, because there is no explicit training in visual spatial skills in schools, the sex difference may reflect gender differences in extra-curricular activities such as participation in sports and computer use.

Data

DOT Data

To link the sex differences documented in the last section to occupational segregation, we use information on job skill requirements taken from the 1977 and 1991 editions of the DOT. The DOT, first published in 1939, was originally intended to help match workers with appropriate jobs. It rates each of several thousand occupations along a number of dimensions such as aptitudes, temperaments, interests and physical demands. In Table AI of the appendix, we describe the DOT measures that we believe are most closely linked to the sensory, motor and spatial aptitudes that consistently show sex differences, as outlined in the previous section.

The DOT measures were not derived with the intent to measure the same skills and aptitudes in which researchers have documented sex differences. Our mapping, as summarized by our hypotheses of expected signs of any male/female sex difference, is necessarily rough.

A couple of comments are warranted before proceeding. First, the evidence for sex differences in the senses of taste and smell are at best mixed, and the explanations include corresponding sex differences in lived experience. This leads to the direct possibility that the sex segregation in occupations due to some other factor leads to the measured sex differences in the senses of taste and smell.

Second, in the area of motor skills, as noted above a way to organize the sex differences is in the categories of fine and gross motor skills. Many of the skills and aptitudes with a documented female advantage are considered fine motor skills and, as Halpern (2012) observes, many studies support such a generalization. The DOT categories of fingering, finger dexterity, handling and motor coordination—the ability to coordinate eyes and hands or fingers with speed and accuracy—are more clearly associated with this category. Eye-hand-foot coordination—the coordination of hands and feet with visual stimulae—we view to involve arm and leg coordination which are gross motor abilities. Clerical perception—the ability to perceive details in tabular or verbal input—has been long associated with the female advantage in perceptual motor skills, but also, controversially, has been used to argue females are better suited for clerical jobs. Finally, we are agnostic about the coding of manual dexterity, which involves working with both arms (a male advantage) and hands (a female advantage).[7]

Occupations

To examine male-female occupational segregation and its relationship to job skill requirements, we link the DOT measures to occupations in the decennial Censuses from 1970-2000, and the 2012 3-year American Community Survey (denoted as 2012). We use the crosswalk developed by Blau et al. (2013) to convert occupations in the earlier Census years and the ACS to the 2000 Census occupational coding (see details in the Data appendix.) The DOT uses an internal coding system, but the 1977 data are also linked to a CPS file that provides 1970 Census occupational codes. We use these to match both 1991 and 1977 DOT codes to 2000 Census occupations. In this way, we were able to link DOT ratings to 476 of the 505 Census occupational codes. (See the Data appendix for a further description of this process.) Because the DOT contains more detail than the Census occupation coding scheme (so that each Census code contains a number of DOT occupations), we average the ratings across all DOT occupations within a Census code, with weights corresponding to that occupation's share of employment. This means that, although most of our DOT measures are categorical, they are continuous within our data. When possible, we assign occupations their 1977 DOT measures for the 1970 and 1980 Censuses, and the 1991 DOT measures thereafter. This is not possible with the

[7] We do not make use of the DOT physical demand codes kneeling, climbing, balancing, stooping, crouching, crawling, talking and reaching. We also exclude the aptitude form perception (the ability to perceive pertinent detail in pictures and graphs) and the physical demands accommodation (the adjustment of the eye to bring things into focus), and field of vision.

physical demands[8] and certain environmental conditions, however, which are only available in 1991; for these measures, we use the 1991 measures for all years.

Empirical Framework

Our objective is to estimate Duncan indices of gender occupational segregation net of any gender occupational selection on occupational differences in the DOT sensory, motor and spatial attributes. The Duncan index is defined as

$$D = (0.5) \bullet \sum_j \left| m_j - f_j \right|$$

where f_j is the fraction of all employed women who work in occupation *j* and m_j is the fraction of all employed men who work in occupation *j*. The index, which ranges between 0 and 1, is commonly interpreted to indicate the proportion of women or men who would need to change occupations if the occupational distribution of men and women were to be the same.

To proceed, we start by estimating the relationship between the DOT measures and the relative probability that men and women select into an occupation. Specifically, we regress the log odds of male to female employment in an occupation on the skill measures (plus a set of controls, in some specifications.) The log odds are defined as:

$$(1) \qquad l_j = \ln\left(\frac{\dfrac{m_j}{(1-m_j)}}{\dfrac{f_j}{(1-f_j)}} \right)$$

The term $f_j / (1 - f_j)$ represents the odds that a randomly selected, employed female works in occupation *j*. The ratio of these odds for men and women tells us about the relative

[8] Excepting physical strength, which is available in both years.

likelihood that men and women select into occupation *j*.[9] Our main regression equation is:

(2) $$l_j = \alpha + \beta S_j + \gamma X_j + \varepsilon_j$$

where S_j is a measure of the skill content in occupation *j*, and the X_j are controls (explained in more detail below.)

We use the results of estimating (2) to simulate the effect of removing any differential selection on skills across occupations. To do this, we first predict the log odds for each occupation that would occur if the DOT skills did not differentially affect the occupation choices of men and women. These are:

(3) $$\hat{l}_j = \hat{\alpha} + \hat{\gamma} X_j + \hat{\varepsilon}_j$$

Next, we find the unique occupational shares, $\hat{f}_j$ and $\hat{m}_j$, that solve these log odds and also keep each occupation's total share of employment at its actual levels.[10] Finally, we construct Duncan indices from these predicted shares.

In order to evaluate whether these predicted indices are significantly different from the actual Duncan index in each year, we compare them to a distribution of Duncan indices constructed from 500 rounds of resampling from the actual data. They tell us the probability of observing the given level of the Duncan index in an economy that actually had the same underlying selection behaviour as the actual economy. Because the sample size is large, this procedure produces bounds that are quite narrow. As a result, nearly all

[9] Alternatively, we can write the odds ratio as the male-to-female ratio in occupation *j* over the male-to-female ratio in all other occupations. If *j* is small relative to the labor market, this denominator of this equation is approximately equal to the male-to-female ratio of total employment. The odds ratio therefore tells us about how far the sex ratio in an occupation deviates from the norm for the labor market.

[10] This procedure produces occupation shares m_j and f_j that do not add up to one, which is a problem for the interpretation of the Duncan index. We solve this problem by rescaling so that the shares do add up to one, i.e. by allowing the total number of men and women in the labor market to change. In practice, the changes in the total size of the labor force are fairly small – about 3% for men and 1% for women.

of our estimated Duncan indices are significantly different from the actual Duncan indices at the 1 percent level.

We also estimate the potential implications of gender selection on sensory, motor and spatial skills for the gender earnings gap. We decompose the observed male/female difference in average earnings as a function of average earnings and the proportion of males and females employed, at the occupation level.

(4) $$w^m - w^f = \sum_j (m_j - f_j) \cdot w_j^m + \sum_j (w_j^m - w_j^f) \cdot f_j ,$$

where w_j^i is average earnings in occupation *j* for sex *i*=*m*,*f*, and f_j and m_j are defined as above. The first term on the right hand side of (4) is the part of the difference in average earnings that is due to differences in the employment of males and females across occupations, while the second term is the part due to male/female differences in earnings within occupations. We then simulate the all else equal male/female average earnings gap net of selection on sensory, motor and spatial skills by substituting $\hat{f}_j$ and $\hat{m}_j$ into (4).

An Overview of Gender Occupational Segregation

We begin our analysis in the first row of table 1 with estimates of Duncan index of occupational gender segregation in the American labor market by census year and for 2012 based on ACS data. While the estimates differ slightly in magnitudes from those in Blau et al. (2013), they tell the same story. The change in the Duncan index between 1970 and 1990 is more than 10 percentage points, while in the next 22 years it is less than 4 percentage points. In 2012 just over half of men or women would need to change occupations for the occupational distribution of males and females to be the same.

In the next five next rows we list the five occupations that make the largest contributions to the Duncan index in each year. They are very stable over time—secretaries and administrative assistants make the largest contribution in every year. Registered nurses and bookkeeping clerks appear in four of the five years. In the seventh row we report the proportion of the Duncan index contributed by these top five occupations. It declines gradually from 13.3 to 8.8 percent over the period. This is an initial indication that quantitatively the Duncan index is relatively concentrated in few occupations, as there are 505 occupational categories in each year.[11]

A recent focus of economic research on occupational segregation is STEM occupations. While there are many reasons to focus on these occupations, their contribution to overall gender employment segregation is not one of them. In the next row we report for each year the proportion of the Duncan index represented by segregation in these occupations. It is quite steady averaging around 2.5 percent over the period.[12]

In the final rows of table 1, we report the total number of occupational categories with positive employment in each year, and indicators of the importance of the occupations making the largest contributions to the Duncan index to overall gender segregation. For example, just 25-30 occupations in each year, or just 6 percent of the total number, can account for 50 percent of the Duncan index. There are no STEM occupations in this group, and in 2012 they represented over 29 percent of male employment and 45 percent of female employment. In each year roughly 170 of 505

[11] In Table 1, we report results for all 505 Census occupation categories. Once we move to the analysis of skills, we will be restricted to the 476 occupations that can be matched to DOT codes. This makes very little difference: the Duncan index for our 476 occupations is 0.646 in 1970 (as opposed to 0.644 for all 505 occupations) and 0.508 in 2012 (versus 0.506 for all occupations.)

[12] Our definition of STEM jobs is from the U.S. Department of Commerce (2011).

occupations can account for 90 percent of the Duncan. These results amplify the message of the top 5 occupations. Gender occupational segregation is a story that is concentrated in a relatively small number of occupations.

Gender occupational selection on aptitudes

We next examine the selection of females and males into occupations on their sensory, motor and spatial attributes. In tables 2 and 3, we report, for 1970 and 2012, the results of estimating equation (2) for each of our DOT attributes separately, omitting any controls for additional occupational characteristics (i.e., *X*). In the second column of the tables we report the expected sign of the estimate based on the research of sex differences in the skill as summarized above (see also table A1 in the appendix). We normalize the skill measures to have mean zero and standard deviation one, so the estimates are interpreted as the change in the log odds associated with a one standard deviation increase in a skill. Note that any change in the coefficients across years could result from changes in the occupational distribution of employment and/or changes in the DOT coding of occupations.[13] Results that use constant occupational coding, with either the 1977 or 1991 DOT measures, produce very similar results.

To provide some context for the estimates for these attributes, we start in table 2 presenting the results for some DOT measures that may be more familiar and intuitive. In the first row are the estimates for the physical skill "strength". It is generally acknowledged that males have a biological advantage in strength, and it may be among the first skills to come to mind when thinking about gender differences in skills and attributes. The results show that jobs with higher demands for physical strength have

13 As noted above, for some attributes we have only one set of codes so the results in table 3 can be directly interpreted as due to the changing distribution of employment

significantly higher male, relative to female, employment: a one standard deviation increase in the physical strength measure is associated with a 0.733 increase in the log odds of male employment in 1970, and an increase of 0.995 in 2012. In 2012, the odds of male employment are roughly 270 percent (exp(0.995)) higher than the odds of female employment in a job one standard deviation above the mean in physical strength. The R-squared of this regression is quite large as well: it indicates that physical strength alone can account for between 14.0% (1970) and 32.1% (2012) percent of the variation in log odds across occupations.

The next two rows are for some cognitive measures of the language and math skills required in the occupations. The DOT General Education Development (GED) scales are based on the typical progression of curricula taught at primary, secondary and tertiary schools in the US. Compared to physical strength these measures have relatively little traction to account for the log odds ratio—the estimates are generally small, as are the R-squareds.

In table 3 are the results for the sensory, motor and spatial aptitudes. In the first panel are the estimates for the sensory skills—color vision, visual acuity, auditory sensitivity, the sense of taste and smell and feeling. The results for color vision and color discrimination are not of the expected sign, while the estimates for the remaining skills are. Larger estimates are observed for far acuity and the two measures of auditory sensitivity. The noise attribute alone can account for 44% of the variation in the data in 2012, and the estimated association with the log odds ratio for this attribute in each year is larger than the estimate for physical strength.

Estimates for the motor skills are presented in the next panel. Here most of the estimates are of the expected sign, with the exception of motor coordination, and handling in 2012. As noted above, the manual dexterity attribute involves both arms and hands and thus we do not have a definitive prediction of a sign for the effect. The result here indicates a positive association with male employment. The estimated association for this attribute, along with those for eye-hand-foot coordination and clerical perception, is relatively large, especially in the 2012 data.

In the final panel are the results for spatial attributes. For both measures of spatial perception the estimates are right signed and very large –in fact, typically larger than the estimated coefficient on physical strength. The estimate for spatial skills falls by about 1/3 from 1970 to 2012; the coefficient on depth perception, however, increases slightly over this time period. By 2012, this single skill measure can account for 41.5% of the variation in log odds ratio.

The fact that several of the estimated coefficients are of the wrong sign in Table 3 could be explained by the fact that jobs characteristics are not independent of one another. Men may work in jobs that are more reliant on color vision, for example, because these jobs also demand aptitudes for which they are relatively advantaged, or because these jobs have other characteristics that men tend to value more than women. We first explore the role of general job characteristics in explaining our results by adding a broad set of controls to the regressions. These are the measures of GED math and language intended to capture the overall cognitive demands of an occupation; the physical strength measure, intended to capture the overall physical demands of an occupation; an indicator for whether a job requires the DOT temperament “Dealing with people”; and an indicator for whether the job requires the DOT worker function

“Things”, which indicates the complexity of the relationship to things in the occupation. The results of these regressions are shown in Table 4.

The addition of these controls attenuates the relationships for some of the more empirically important skills identified in table 3. For example the estimates for the spatial attributes, noise and clerical perception are smaller, yet still relatively large, here. The controls also change the signs on a number of the characteristics. The measures for the perception of color are now mostly of the anticipated sign, as are the results for motor coordination and handling. The estimates for manual dexterity also flip sign. Finally, the estimates for some attributes are larger here—tasting and smelling is now larger and negative, as is feeling. These changes are consistent with the possibility that, for example, the coefficients were biased upwards in the non-controlled regressions because men tend to work in jobs that rely more heavily on all physical skills.

Of course, these regressions may also overstate the selection effect for specific skills if our skill measures are highly correlated with each other. In Table 5, we show what happens when we add all of our skills together in groups, along with the controls.

In the sensory regressions, all the estimates retain their expected signs. Relatively large estimates are observed for noise, far acuity and to a lesser extent feeling. In the motor group, manual dexterity flips sign once again in this specification, and motor coordination is again wrong signed, although neither is individually empirically important here. Finger dexterity emerges as the skill in this group with the largest impact on the log odds ratio, while the estimates for many of the other skills are no longer statistically significant.

Finally, the coefficients on spatial skills and depth perception fall when they are added to the regression together. While the coefficient on spatial skills falls to zero in 2012, the coefficient on depth perception is large and significant in both years.

As a final exercise we examine what happens when we add all of our skill measures to the regression at once, along with the controls. The results from these regressions are shown in Table 6. In the sensory group, most skills maintain the expected sign. Noise and feeling stand out as skills with relatively large and statistically significant relationships with the log odds ratio. In the motor skills group the results are more mixed with a few “wrong” signs. Here handling and clerical perception stand out for the magnitude of the right signed estimated relationships. Finally both measure of spatial skills remain statistically significant although the magnitude of the relationships is diminished somewhat.

In choosing our additional controls we have confined our attention to cognitive skills, physical strength and abilities with persons and things reflecting recent economic research on the role of these attributes. In the appendix we report how the results change when we add additional controls to the model. In the first experiment we add the ratio of male to female wages and average weekly hours[14] at the occupational level as controls. These are intended to capture variation in the differential reward to females and males across occupations and any penalties in occupations for personal restrictions on working long hours. These additions have little effect on the results. As a second experiment we add as controls the five O*NET[15] occupational characteristics that Goldin (2014) hypothesizes are positively correlated with the linearity of the hours/wage relationship.

[14] Weekly hours are provided in intervals in the 1970 Census data; we use the midpoint of each interval to impute weekly hours.

[15] The Occupational Information Network (O*NET) is a successor to the DOT we use in the paper, produced by the US Department of Labor.

Occupations with more linear hours/wages relationships should have smaller residual sex differences in compensation and therefore, all else equal, be more attractive to female workers. While some of these factors are individually very significant in the log odds regressions, they have minimal impact on the contribution of the sensory, motor and spatial skills. Next, we omit nominally duplicate skill measures (e.g., color vision and color discrimination), which also has little impact on the results. Finally, given recent interest in the role of social skills in the labor market, we have also controlled for alternative DOT measures of this ability. In addition to the temperament "dealing with people" these are the interest "activities involving contact with people" and people component of the worker function indices. Either controlled for individually or simultaneously, these measures of the social dimension of the occupation have little impact on our estimates of occupational selection on sensory, motor and spatial aptitudes.[16]

We have also investigated generational changes in the importance of selection on these attributes. We calculate the log odds ratio separately for the age groups 18-24, 25-34 and 35-64. We next run the pooled regression testing for interaction effects between dummy variables for the younger age groups and the DOT aptitude measures. The estimates of these interactions for both age groups and in both years are uniformly statistically insignificant. There is no evidence by this measure that younger and older workers select differently into occupations on these characteristics. We return to this split of the data by age in our discussion of the adjusted Duncan indices below.

The message of this analysis is that estimated relationships between the male to

[16] We have also estimated models that use either only the 1970 or 1991 DOT definitions in both the 1970 and 2012 data. A summary of the results is reported in the appendix.

female log odds ratio and the DOT skill measures is, for the majority of job attributes, of the sign predicted by the cited research on sex differences. In more comprehensive specifications, a challenge to isolating the relationships for individual skills is the multicollinearity among them.[17] That said, in table 6 the attributes/skills of noise, feeling, spatial and depth perception stand out as making an empirically unique contribution to the log odds employment ratio. We note that the analogues of these DOT skills in the research literature—hearing, hand and finger sense and spatial perception—are among the least controversial and widely acknowledged sex differences, and ones that have been documented at young ages.

The Association of Gender Occupational Selection on Aptitudes with Gender Occupational Segregation

The preceding evidence indicates that males and females select into occupations in ways consistent with research on sex differences in sensory, motor and spatial abilities. We next ask whether this selection has any meaningful implication for the occupational segregation we observe in the labor market?

In table 7 we provide estimates of adjusted Duncan indices following equation (3). These estimates remove the impact of any sex difference in occupational selection on the indicated attribute. We present both unconditional results, and results conditional on any selection on our controls for occupations' cognitive demands and their demands for interactions with people and things.

[17] We have estimated the models reported in table 6 using the shrinkage estimator Least Absolute Shrinkage and Selection Operator (LASSO). For 1970, the estimates from this method are zero for color vision, manual dexterity and motor coordination. For 2012 the estimates are zero for color vision, near acuity, hearing, manual dexterity, motor coordination and eye-hand-foot coordination. For both years, the estimates for noise, feeling, handling and the spatial measures are mostly modestly smaller that in table 6. These results are available from the authors on request.

From an economic standpoint, the changes induced by removing the influence of many of the skills individually is quite small. For 1970, in the column with no controls, over the sensory and motor attributes the predicted Duncan indices range from 0.612 to 0.651, compared to an actual Duncan index of 0.646 in that year. These represent reductions in the index of between 0.7 and just over 5 percent. Adding controls—allowing selection on these additional variables—to the regressions has little effect on the inference.[18] In 2012 the results for these attributes range over a larger interval from higher predicted Duncan indices to predictions that are lower than the actual by almost 13 percent (i.e., for noise).

On an individual basis the spatial attributes have more traction. Conditional on selection on the other controls, the predicted Duncan removing the gender differential in selection on depth perception is about 10 percent lower than the actual in both 1970 and 2012.

Table 8 shows the results from removing the impact of groups of skills together. This has a much larger effect on the Duncan index. If just the sensory skills were removed, the results suggest that the Duncan index would have fallen to about 0.588 in 1970 and to 0.437 in 2012, a 10-15 percent reduction relative to the actual prevailing levels. The effect of removing selection on motor skills or spatial skills is quite similar. If selection on all of our skill measures is eliminated at once, the results suggest that the Duncan index would have been about 23 percent lower in both years, 0.5 in 1970 (close to its current level) and about 0.39 in 2012.

The impact of selection on these aptitudes is modestly amplified in the

[18] In constructing our predicted log odds, we continue to allow differential male-female selection on the controls. The controls themselves have a large effect on the Duncan index; if we shut down selection on the controls only, the Duncan index falls to 0.543 in 1970 and 0.446 in 2012.

occupations making the largest contribution to the Duncan.[19] In the small set of occupations that can account for 50 percent of the Duncan, negating selection on all aptitudes reduces the index by 26 percent in 1970 and 29.5 percent in 2012. In the group representing 90 percent of the Duncan negating selection on the aptitudes reduces the Duncan by 25 percent in each year.

The association between the aptitudes we consider and gender based occupational segregation appears fairly constant over time. Another perspective on this finding is provided in table 9 were we present adjusted Duncan indices by the age groups 15-24, 25-34 and 35-64.[20] First note that the actual Duncan index rises with age, modestly in 1970 and by over 10 percent in 2012. Second, while the proportionate distance between the actual Duncan and the predicted Duncan negating selection on the aptitudes differs by age it is sizable for all age groups. In 1970s there is a monotonic increase in the impact of adjustment, from almost 17 percent for 18-24 years olds to almost 24 percent for 35-64 year olds. In 2012 the relationship is U shaped, the impact ranging from 19.6 percent at ages 25-34 to almost 25 percent at ages 35-64. Therefore, there is enduring relevance of these aptitudes to employment segregation over the period, and over the cohorts of workers, we analyze.

Of course in both years there is a significant part of gender occupational segregation that remains unaccounted. In part the contribution of the analysis, however, is the progress made over a more traditional account that focuses on cognitive skills and strength or, more recently, people skills and facilities with things. The contribution of

[19] The estimates underlying the following conclusions are not reported but are available from the authors on request.

[20] We restrict our attention here to 470 occupations with positive employment for both males and females among young workers.

these factors to the Duncan, as captured by our control variables and conditional on the sensory, motor and spatial aptitudes, is more modest—the estimated Duncan would about 9 percent lower in 1970 and 10 percent lower in 2012. Taken together the adjusted Duncan, negating selection on both the aptitudes and controls, is roughly one-third lower than the actual Duncan in both years. In each year over two-thirds of the decrease is accounted by negating the selection on the sensory, motor and spatial aptitudes.[21]

Implications for the Gender Earnings Gap

We have shown that accounting for differential gender based occupational selection on sensory, motor and spatial job aptitudes leads to substantially lower estimated occupational segregation. We next investigate whether this reduction in segregation has an impact on the gender earnings gap. In the top panel of Table 10 we present the analysis for 2012 using equation (4). The male/female earnings gap was just over $12,000 (in 2002 constant dollars) in this year, of which almost 29% was due to differences in the distribution of men and women across occupations.[22] In the next row we normalize the results to the 476 occupations we use in the Duncan analysis, which makes very little difference.

In the next rows of the panel we calculate the wage gap using the predicted distributions of men and women across jobs, after negating selection on the aptitudes. Somewhat surprisingly, the wage gap *increases* when negating selection on these skills,

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[21] Strictly speaking, the change in the Duncan index that results from removing selection on skills and controls cannot be decomposed into a piece accounted for by skills and a piece accounted for by controls. This is because the effect of skills and controls on the Duncan is non-linear when the difference between the male and female share switches signs. In practice, adding up the change induced by skills and the change induced by controls produces a figure that is very close to the total change in the index when both skills and controls are included together. This occurs in spite of the fact that about 1/3 of all occupations switch from male to female dominated or vice versa when we remove the effect of skills or controls, because the contribution of these occupations to the Duncan index is very close to zero.

[22] The results are very similar if we use the alternative decomposition in which the difference in the occupational shares are weighted by female wages.

as a result of an increase in the across occupation component. This is true for each set of aptitudes individually, as well as for the estimate when selection on all aptitudes is negated simultaneously.

A closer inspection of the data shows that in most cases a small number of occupations play a large role in this result. Negating selection on the sensory aptitudes or on all aptitudes, it is reductions in the proportion of females who are nurses, nursing home health aides and doctors that drives the increase in the cross-occupation component. For the bulk (roughly two-thirds) of the remaining occupations the impact of adjustments in female and male employment is to lower the cross occupation component. While the contributors to the increase in the cross occupation component when negating selection on perceptual motor and spatial aptitudes are more numerous, doctors and accountants have a leading role. Here adjustments in the proportion of males and females in roughly 58 percent of occupations reduce the cross-occupational term.

How the estimate for all aptitudes plays out across the occupational earnings distribution is presented in figures 1 and 2 for females and males respectively. In figure 1, occupational selection on sensory, motor and spatial aptitudes (moving from the predicted density to the actual density) decreases the mass between $20,000 and about $35,000 and increases the mass between $40,000 and about $55,000. For males (figure 2) the impacts are smaller and just the opposite—more mass at lower earnings levels and less mass at higher earnings levels.

Given current interest in the STEM sector, in the last rows of the first panel of table 10 we decompose the wage gap separately for STEM and non-STEM occupations. The earnings gap in the STEM fields is mostly across occupation while the within occupational component is very small. This is consistent with other evidence that the gender wage gap within STEM occupations is smaller than its counterpart outside the STEM sector (U.S. Department of Commerce 2011). In contrast in non STEM occupations the across occupation component of the wage gap is on balance relatively small, while the within occupation component accounts for most of the aggregate gap.

Negating selection on our selected aptitudes increases female representation within the STEM sector. The proportion of females in STEM jobs rises to 3.2% (from 2.7%) and the proportion of males in STEM jobs falls from 8.0% to 7.0%. As a consequence the across occupation component of the STEM wage gap falls by almost 29 percent. Outside the STEM sector, negating selection on these aptitudes increases the cross-occupation component. Therefore, aptitude biased occupational selection plays a positive role for women in non-STEM fields.

In the second panel of table 10 we repeat the analysis for 1970. In this year the earnings gap is about 50 percent larger and the proportionate contribution of the across occupation component is about one-half as large. While the effects are more modest, negating selection on the sensory, motor or spatial attributes again increases both the across occupation component and the total earnings gap. Negating selection on all attributes however, lowers both the total gap and the across occupation component. The results for the STEM sector are very similar to the results for 2012. In the non STEM sector, however, aptitude biased selection is observed to increase the earnings gap, the opposite of the result for 2012.

Conclusions

Research from a number of fields suggests that males and female differ, on average, in a number of sensory, motor and spatial aptitudes that are potentially important for occupational choice. We bring these findings to the puzzle of persistent gender based occupational segregation in the US labor market. Our results suggest that males and females select into occupations in ways predicted by this research. For example, males have been found to have a higher tolerance of noise and are found disproportionately in noisy jobs. We estimate that occupational segregation is higher than it would otherwise be as a result of this selection. Conditional on our mapping of the research on sex differences in the aptitudes into DOT occupational attributes, in both 1970 and 2012, we estimate that absent this selection the Duncan index of occupational segregation would be 23 percent lower than its observed level.

The main implication of this research for research and policy is the identification of these skills as important correlates of the gender occupational segregation. However, operationalizing these findings in a policy context depends on discovering the sources of the gender differences in these aptitudes. For example the response to aptitude differentials due to biology or very slow changing environmental stimuli in early childhood might differ from the response to differentials due to environmental and institutional factors that are a function of place and time. The answer to this question is being actively pursued in a number of fields.[23]

The findings also highlight a lesson from the literature on sex differences for research on the task content of jobs. The choice of specific DOT or O*Net skills to represent specific tasks may not be innocuous, particularly if differences across genders

[23] Baker and Cornelson (2016) investigate how the increase is females' sports participation due to Title IX affected the spatial content of female employment.

are to be compared or contrasted.[24]

In their recent study of gender occupational segregation Blau et al. (2013) observe that for significant desegregation in the future, “women would need to begin to make significant inroads into areas where they have not so far, especially predominantly male blue-collar jobs, and continue to build on their gains in STEM fields; and/or men would need to enter predominantly female occupations in much larger numbers than they have in the past” (p. 490). Our results point to some hypotheses of why these inroads are yet to be made.

[24] For example the DOT aptitudes Finger Dexterity (a fine motor skill) and Eye-Hand-Foot coordination (a gross motor skill) are used to represent routine and non routine manual skills respectively in the Autor et al. (2003) taxonomy of tasks. These skills are shown in tables 2-4 to have strong relationships with the log odds of male employment, particularly when used in isolation. Correspondingly, Autor and Price (2013) report persistent gender gaps between 1960 and 2010 in both routine and non routine manual skills employment using this taxonomy. In contrast Black and Spitz-Oener (2010) report large changes in the gender differences between 1979 and 1999 in routine and non routine manual tasks for West Germany using broader definitions of the associated aptitudes and activities.

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Appendix

Table A1 – DOT measures of sensory, motor and spatial skills and aptitudes

DOT measure(s) (type)	Scale	Expected coefficient on "male"	Description**	Occupations with highest/lowest rating
Color discrimination (aptitude)	1 to 5*	-	"The ability to match or discriminate between colors in terms of hue, saturation, and brilliance. Ability to identify a particular color combination from memory and to perceive contrasting color combinations."	Misc. personal appearance workers/ boilermakers
Color vision (physical demand)	0 to 3	-	"Ability to identify and distinguish colors"	Motion picture projectionists/ mathematicians
Near visual acuity (physical demand)	0 to 3	-	"Clarity of vision at 20 inches or less."	Tellers/ dancers and choreographers
Far visual acuity (physical demand)	0 to 3	+	"Clarity of vision at 20 feet or more"	Bus drivers/ lawyers
Hearing (physical demand)	0 to 3	-	"Perceiving the nature of sounds by ear."	Lawyers/ dancers and choreographers
Noise (environmental condition)	1 to 5	+	"The noise intensity level to which the worker is exposed in the job environment"	Misc. construction operators/ chiropractors
Taste/smell (physical demand)	0 to 3	-	"Distinguishing, with a degree of accuracy, differences or similarities in intensity or quality of flavors or odors, or recognizing particular flavors or odors, using tongue or nose."	Meter readers, utilities/ plasterers and stucco masons
Feeling (physical demand)	0 to 3	-	"Perceiving attributes of objects, such as size, shape, temperature, or texture, by touching with skin, particularly that of fingertips."	Chiropractors/ actuaries

Finger dexterity (aptitude)	1 to 5*	-	"The ability to move the fingers and manipulate small objects with the fingers rapidly or accurately."	Dentists/ clergy
Fingering (physical demand)	0 to 3	-	"Picking, pinching, or otherwise working primarily with fingers rather than with the whole hand or arm as in handling."	Tellers/ dancers and choreographers
Motor coordination (aptitude)	1 to 5*	–	"The ability to coordinate eyes and hands or fingers rapidly and accurately in making precise movements with speed. Ability to make a movement response accurately and swiftly"	Dancers and choreographers/ meter readers, utilities
Eye-hand-foot coordination (aptitude)	1 to 5*	+	"The ability to move the hand and foot coordinately with each other in accordance with visual stimuli."	Dancers and choreographers/ boilermakers
Clerical perception (aptitude)	1 to 5*	-	"The ability to perceive pertinent detail in verbal or tabular material. Ability to observe differences in copy, to proofread words and numbers, and to avoid perceptual errors in arithmetic computation. A measure of speed of perception is required in many industrial jobs even when the job does not have verbal or numerical content."	Computer programmers/ pressers, textile, garment and related materials
Manual dexterity (aptitude)	1 to 5*	?	"The ability to move the hands easily and skillfully. Ability to work with the hands in placing and turning motions…manual dexterity involves working with the arms and hands…Finger movements may or may not accompany the exercise of manual dexterity."	Veterinarians/ meter readers, utilities
Handling (physical demand)	0 to 3	-	"Seizing, holding, grasping, turning, or otherwise working with hand or hands."	Optometrists/ dancers and choreographers

Spatial (aptitude)	1 to 5*	+	"The ability to think visually of geometric forms and to comprehend the two-dimensional representation of three-dimensional objects. The ability to recognize the relationships resulting from the movement of objects in space."	Optometrists/ insurance sales agents
Depth perception (physical demand)	0 to 3	+	"Three-dimensional vision. Ability to judge distances and spatial relationships so as to see objects where and as they actually are."	Bus drivers/ sociologists
Control Variables				
GED language	1 to 5		"…though language courses follow a…pattern of progression in primary and secondary school, particularly in learning and applying the principles of grammar, this pattern changes at the college level. The diversity of language courses offered at the college level precludes the establishment of distinct levels of language progression for these four years. Consequently, language development is limited to five defined levels of GED."	Clergy/ parking lot attendants
GED math	1 to 6		"The description of the various levels of language and mathematical development are based on the curricula taught in schools throughout the United States. An analysis of mathematics courses in school curricula reveals distinct levels of progression in the primary and secondary grades and in college. These levels of progression facilitated the selection and assignment of six levels of GED for the mathematical development scale."	Mathematicians/ parking lot attendants
Temperament – dealing with people	0 to 1		"…interpersonal relationships in job situations beyond receiving work instructions."	Recreational therapists/ dancers and choreographers

Interests - things	0 to 1	"Things Functions can be divided into relationships based upon the worker's involvement with either machine and equipment (machine related) or with tools and work aids (non-machine related)...Things Functions also represent levels of complexity based on the worker's decisions or judgements."	Parking lot attendants/ audiologists
Physical strength	1 to 5	"This factor is expressed by one of five terms: Sedentary, Light, Medium, Heavy and Very Heavy"	Therapists, all other / statisticians

* Reverse coded in original data; re-labelled to be in increasing order of skill. ** Source—US Department of Labor (1991).

Data Methods

Converting Census data into 2000 Census occupation codes

In our analysis, we use the 1% Census samples provided by the IPUMS website, as well as the 2012 three-year ACS. We restrict the sample to 18-64 year olds who are employed in the civilian labor force, with non-allocated occupation codes.

To ensure comparability with previous work on occupational segregation, we use the 2000 Census occupation codes throughout our analysis. To convert the 1970 Census data to the year 2000 codes, we follow the procedure outlined in Blau et al. (2013). We start by converting the 1970 data to 1980 codes using the gender-specific crosswalk provided by the Census Bureau (available on IPUMS at https://usa.ipums.org/usa/resources/chapter4/occ_70-80.pdf). There were minimal changes between the 1980 and 1990 coding systems. For 1980 occupations that were combined into a single 1990 occupation (six pairs), we simply add the number of men/women in each 1980 occupation to arrive at the 1990 total. For the 1980 occupations that were split in the 1990 coding system, we redistribute the number of 1980 incumbents into the 1990 codes based on the distribution of employment in 1990. Finally, we use the crosswalk developed by Blau et al. (2013) to convert the data into the 2000 Census codes.

The 2012 ACS occupation codes are similar to those used in the 2000 Census. For the occupations that did experience changes from the 2000 Census to the ACS, we follow a procedure that is similar to that used in converting the 1980 data to 1990 codes.

Converting DOT data to 2000 Census occupation codes

The DOT77 data was obtained from a 1971 CPS file, augmented with DOT ratings, which is available from the ICPSR website. This file contains both the DOT occupational coding and the 1970 census occupational coding. Because each 1970 occupation contains several DOT occupations, we calculate the DOT rating for each 1970 occupation using an employment-weighted mean. We use procedures similar to that described in the Census data to convert the ratings to the 2000 Census occupation coding, taking employment-weighted means at each step. Note that the crosswalks used in this process are not gender specific; each 2000 Census occupation is given a single DOT rating, not a separate rating for men and women.

The DOT91 data was also obtained from the ICPSR website. DOT91 ratings are only available for the 1991 DOT occupational coding. Most occupations had the same coding in 1977 and 1991. A list of exceptions was available in the ICPSR documentation, which was used to convert the remaining occupations (do-files available upon request.) Once the data was consistent with the 1977 coding system, the 1991 data was merged onto the 1971 CPS file, and was then converted to the 2000 Census codes in the same was as the 1977 data.

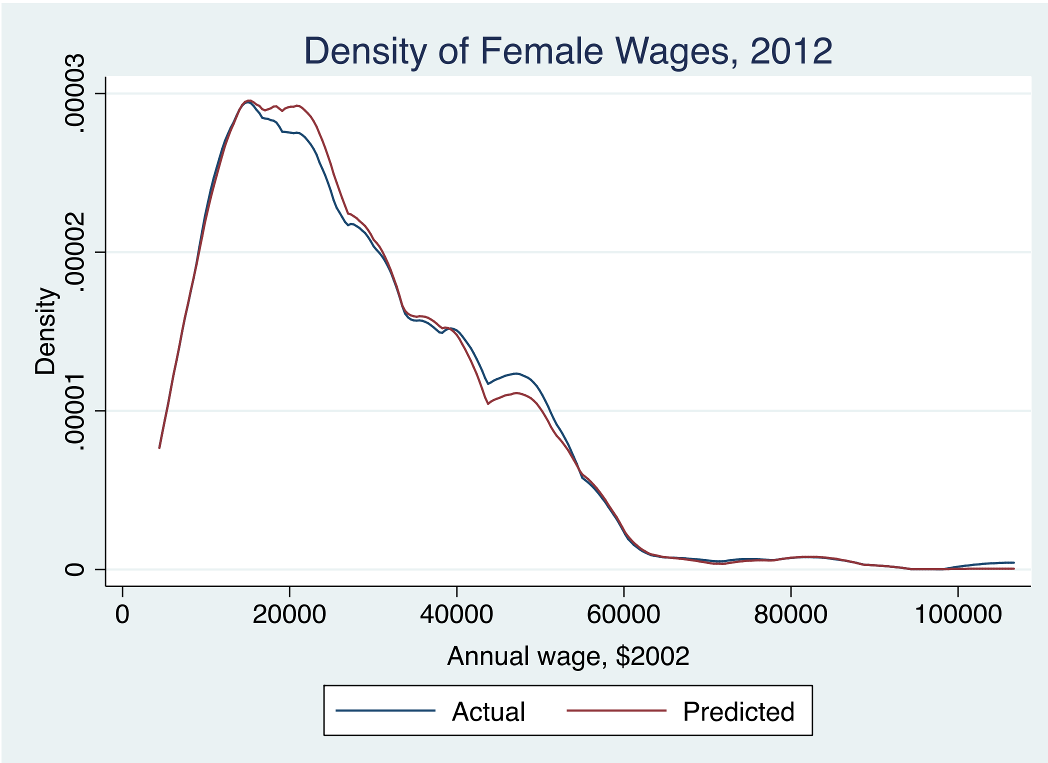
There are 505 occupations in the 2000 occupation coding system. Of these, 478 had non-zero employment for both men and women, in both 1970 and 2012. Another 2 occupations could not be matched to the DOT data, resulting in a final sample of 476 occupations.

Table A2- Sensitivity Analysis- Changes in the specification of DOT skills and in the control variables

Alternative specification	Results (Based on the full specification with all variables and controls.)
Controlling for the ratio of wages and hours worked	The results are similar. Adding these to the controls, the predicted Duncan indices (negating skill selection) are 0.497 and 0.389, compared to 0.497 and 0.390 in our main analysis.
Controlling for Goldin's (2014) O*NET measures of hours/wages linearity	The results are similar. Goldin's measures are available for 415 of our 476 occupations. For these 415 occupations, the actual Duncan index was 0.652 in 1970 and 0.511 in 2012. Using our standard set of controls and negating skill selection leads to predicted Duncan indices of 0.515 and 0.410, respectively. Adding in Goldin's measures as additional controls, the predicted Duncan indices are 0.529 and 0.417. The portion of the Duncan indices that is "explained" by our skill measures is therefore about 20% for this set of jobs without Goldin's measures, and about 18.5% with Goldin's measures.
Using only one of color discrimination or color vision	The results are similar if we drop either of these variables. The predicted Duncan index ranges from 0.496-0.499 in 1970 and from 0.390-0.391 in 2012, depending on the combination used.
Using only one of fingering or finger dexterity	The results are similar if we drop either of these variables. The predicted Duncan index ranges from 0.496-0.510 in 1970 and from 0.390-0.398 in 2012, depending on the combination used
Using only one of finger dexterity or motor control	The results are similar if we drop either of these variables. The predicted Duncan index ranges from 0.496-0.510 in 1970 and from 0.390-0.398 in 2012, depending on the combination used.
Using only one of manual dexterity or motor control.	The results are similar if we drop either of these variables. The predicted Duncan index ranges from 0.496-0.498 in 1970 and from 0.390-0.395 in 2012, depending on the combination used.
Controlling for alternative measures of the social skill of employment—interests "activities involving contact with people", and worker function "people"	Using the "interests – activities involving contact with people" measure or the "people" component of the data-people-things measure in place of "temperament – dealing with people" changes very little, as does including all three measures simultaneously. If all three measures are used, the Duncan index negating selection on all skills (with controls) is 0.493 in 1970, as opposed to 0.497 in our main analysis. In 2012, it becomes 0.385, as opposed to 0.390 in our main analysis.

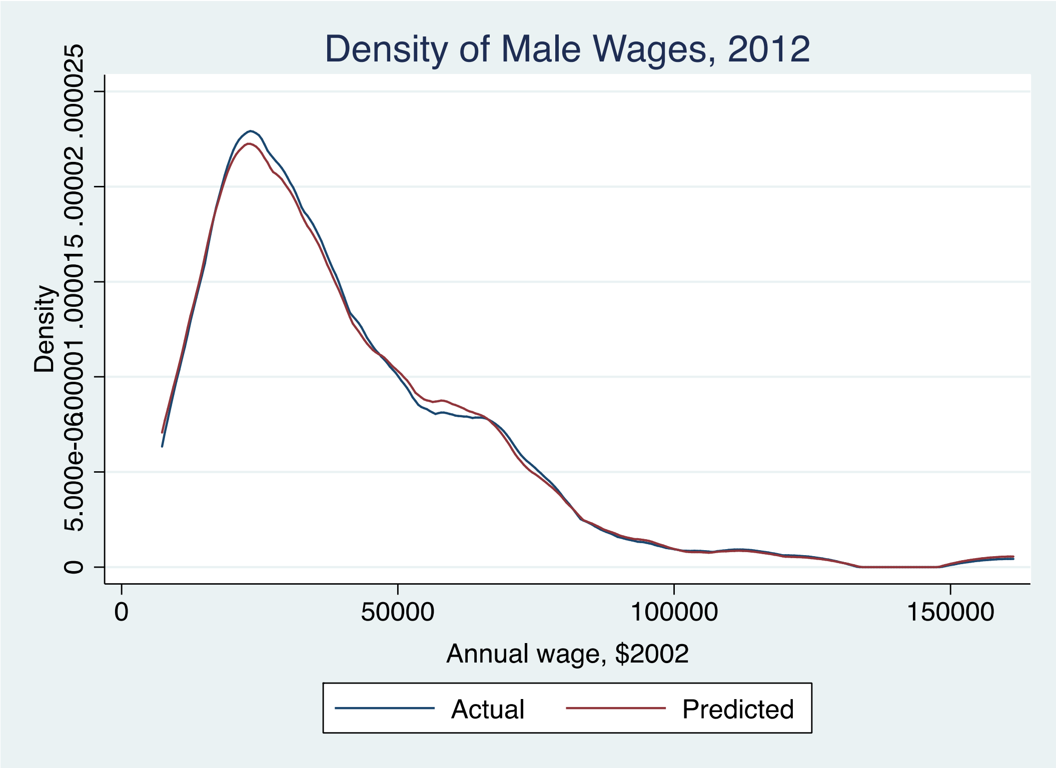
Alternative specification	**Results** **(Based on the full specification with all variables and controls.)**
Switching to 1991 DOT definitions for both years	The coefficients on far acuity, feeling, eye-hand-foot coordination and spatial become larger in magnitude for 1970; the coefficients on tasting-smelling and depth perception become smaller in magnitude. The only variable that changes significance is tasting-smelling, which would not have been significant in 1970 if the 1991 definitions had been used. If 1991 definitions are used, the predicted Duncan index (negating selection on all skills, with controls) becomes 0.507 in 1970, as opposed to 0.497 in our main analysis.
Switching to 1977 DOT definitions for both years	The coefficient on noise becomes larger in magnitude for the 2012 regression, while the coefficient on feeling becomes less significant. Both variables remain highly significant. If 1977 definitions are used, the predicted Duncan index (negating selection on all skills, with controls) becomes 0.377 in 2012, as opposed to 0.390 in our main analysis.

Figure 1: The actual and predicted (negating occupational selection on sensory, motor and spatial aptitudes) densities of female earnings.



Notes: Authors' calculations from the 2012 American Community Survey. The actual density is for the occupational distribution of earnings in the analysis sample. The predicted density is constructed using the predicted distribution of individuals across occupations negating any selection on the DOT sensory, motor and spatial attributes.

Figure 2: The actual and predicted (negating occupational selection on sensory, motor and spatial aptitudes) densities of male earnings.



Notes: Authors' calculations from the 2012 American Community Survey. The actual density is for the occupational distribution of earnings in the analysis sample. The predicted density is constructed using the predicted distribution of individuals across occupations negating any selection on the DOT sensory, motor and spatial attributes.

Table 1: Gender based occupational segregation in the US labor market

	1970	**1980**	**1990**	**2000**	**2012**
Duncan Index	0.644	0.586	0.540	0.519	0.506
Top 5 Occupations	Secretaries and administrative assistants	Secretaries and administrative assistants	Secretaries and administrative assistants	Secretaries and administrative assistants	Secretaries and administrative assistants
	Driver/sales workers and truck drivers	Driver/sales workers and truck drivers	Driver/sales workers and truck drivers	Driver/sales workers and truck drivers	Registered nurses
	Elementary and middle school teachers	Bookkeeping, accounting and auditing clerks	Elementary and middle school teachers	Registered nurses	Driver/sales workers and truck drivers
	Bookkeeping, accounting and auditing clerks	Elementary and middle school teachers	Registered nurses	Elementary and middle school teachers	Elementary and middle school teachers
	Maids and housekeeping cleaners	Registered nurses	Bookkeeping, accounting and auditing clerks	Bookkeeping, accounting and auditing clerks	Nursing, psychiatric and home health aids
% of Duncan Accounted by top 5 Occupations	13.3	12.5	11.5	9.3	8.8
% of Duncan Accounted by STEM Occupations	2.5	2.3	2.4	2.7	2.6
Total Number of Occupations	505	505	505	505	505
Number of Occupations that account for 50% of the Duncan	25	26	28	31	31
Number of Occupations that account for 90% of the Duncan	166	172	177	176	172

Notes: Authors' calculations from 1970-2000 censuses and 2012 American Community Survey.

Table 2: The relationship between the log odds ratio of male to female employment and measures of physical strength, language and math; univariate regressions, no controls

		1970		2012	
	Sign	Coefficient	R^2	Coefficient	R^2
Physical strength	+	0.733*** (0.083)	0.140	0.995*** (0.066)	0.321
GED - language	?	-0.097 (0.090)	0.002	-0.503*** (0.077)	0.082
GED – math	?	0.226** (0.089)	0.013	-0.168** (0.080)	0.009

Notes: Authors' calculations from 1970 census and 2012 American Community Survey. Each estimate is from a separate regression of the log odds ratio of male to female employment at the occupational level on the DOT measure of the indicated skill or aptitude. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 3: The relationship between the log odds ratio of male to female employment and sensory, motor and spatial skills; univariate regressions, no controls

			1970		2012	
		Sign	Coefficient	R^2	Coefficient	R^2
Sensory	Color discrimination	-	0.173* (0.090)	0.008	0.190** (0.080)	0.012
	Color vision	-	0.449*** (0.088)	0.053	0.352*** (0.079)	0.040
	Near Acuity	-	-0.171* (0.090)	0.008	-0.225*** (0.080)	0.016
	Far Acuity	+	0.573*** (0.086)	0.086	0.460*** (0.078)	0.069
	Hearing	-	-0.545*** (0.086)	0.077	-0.795*** (0.072)	0.205
	Noise	+	0.953*** (0.079)	0.237	1.165*** (0.060)	0.440
	Tasting-smelling	-	-0.069 (0.090)	0.001	-0.037 (0.081)	0.000
	Feeling	-	-0.142 (0.090)	0.005	-0.124 (0.080)	0.005
Motor	Fingering	-	-0.394*** (0.088)	0.040	-0.240*** (0.080)	0.019
	Finger Dexterity	-	-0.144 (0.090)	0.005	-0.062 (0.081)	0.001
	Handling	-	-0.011 (0.090)	0.000	0.278*** (0.080)	0.025
	Manual dexterity	?	0.458*** (0.087)	0.055	0.675*** (0.074)	0.148
	Motor Co-ordination	-	0.146 (0.090)	0.006	0.332*** (0.079)	0.036
	Eye-Hand-Foot	+	0.654*** (0.085)	0.111	0.729*** (0.073)	0.172
	Clerical Perception	-	-0.555*** (0.087)	0.080	-0.856*** (0.070)	0.237
Spatial	Spatial skills	+	0.907*** (0.080)	0.214	0.685*** (0.074)	0.152
	Depth perception	+	1.047*** (0.076)	0.286	1.131*** (0.062)	0.415

Notes: Authors' calculations from 1970 census and 2012 American Community Survey. Each estimate is from a separate regression of the log odds ratio of male to female employment at the occupational level on the DOT measure of the indicated skill or aptitude. ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 4: The relationship between the log odds ratio of male to female employment and sensory, motor and spatial aptitudes; univariate regressions, controls

			1970		2012	
		Sign	Coefficient	Partial R^2	Coefficient	Partial R^2
Sensory	Color discrimination	-	-0.180** (0.077)	0.012	-0.266*** (0.064)	0.036
	Color vision	-	0.027 (0.080)	0.000	-0.134** (0.065)	0.009
	Near Acuity	-	-0.182** (0.079)	0.011	-0.116* (0.064)	0.007
	Far Acuity	+	0.636*** (0.073)	0.140	0.430*** (0.060)	0.097
	Hearing	-	0.050 (0.150)	0.000	0.080 (0.122)	0.001
	Noise	+	0.894*** (0.101)	0.143	0.870*** (0.079)	0.206
	Tasting-smelling	-	-0.295*** (0.074)	0.033	-0.211*** (0.060)	0.026
	Feeling	-	-0.412*** (0.074)	0.062	-0.491*** (0.060)	0.126
Motor	Fingering	-	-0.426*** (0.076)	0.063	-0.247*** (0.064)	0.031
	Finger Dexterity	-	-0.407*** (0.075)	0.059	-0.383*** (0.061)	0.076
	Handling	-	-0.266*** (0.091)	0.018	-0.160** (0.075)	0.010
	Manual dexterity	?	-0.169* (0.090)	0.007	-0.210*** (0.081)	0.014
	Motor Co-ordination	-	-0.120 (0.077)	0.005	-0.158** (0.065)	0.012
	Eye-Hand-Foot	+	0.351*** (0.084)	0.036	0.262*** (0.075)	0.025
	Clerical Perception	-	-0.407*** (0.107)	0.030	-0.473*** (0.103)	0.043
Spatial	Spatial skills	+	0.586*** (0.098)	0.071	0.332*** (0.088)	0.030
	Depth perception	+	0.778*** (0.093)	0.129	0.651*** (0.078)	0.130

Notes: Authors' calculations from 1970 census and 2012 American Community Survey. Each estimate is from a separate regression of the log odds ratio of male to female employment at the occupational level on the DOT measure of the indicated skill or aptitude. In each case the additional controls in the regression are the DOT skills GED math, GED language, the physical attribute strength, the temperament for "dealing with people" , and the workers' function "things". ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 5: The relationship between the log odds ratio of male to female employment and sensory, motor and spatial aptitudes; aptitude group multivariate regressions, controls

			1970		2012	
		Sign	Coefficient	Group R^2	Coefficient	Group R^2
Sensory	Color discrimination	-	-0.165 (0.101)	0.505	-0.147 (0.104)	0.629
	Color vision	-	0.086 (0.118)		-0.020 (0.109)	
	Near Acuity	-	-0.040 (0.075)		0.023 (0.060)	
	Far Acuity	+	0.429*** (0.088)		0.272*** (0.067)	
	Hearing	-	-0.172 (0.141)		-0.207* (0.11)	
	Noise	+	0.581*** (0.104)		0.632*** (0.081)	
	Tasting-smelling	-	-0.157** (0.069)		-0.051 (0.053)	
	Feeling	-	-0.219*** (0.077)		-0.290*** (0.063)	
Motor	Fingering	-	-0.123 (0.100)	0.435	0.097 (0.085)	0.541
	Finger Dexterity	-	-0.687*** (0.142)		-0.587*** (0.112)	
	Handling	-	-0.047 (0.101)		-0.016 (0.082)	
	Manual dexterity	?	0.177 (0.136)		0.029 (0.143)	
	Motor Co-ordination	-	0.315** (0.125)		0.206* (0.116)	
	Eye-Hand-Foot	+	0.185** (0.089)		0.183** (0.079)	
	Clerical Perception	-	-0.341*** (0.109)		-0.447*** (0.105)	
Spatial	Spatial skills	+	0.271** (0.107)	0.433	-0.058 (0.098)	0.533
	Depth perception	+	0.650*** (0.106)		0.680*** (0.092)	

Notes: Authors' calculations from 1970 census and 2012 American Community Survey. The estimates are from regressions of the log odds ratio of male to female employment at the occupational level on the DOT measures of the skills or aptitudes in the indicated group in the indicated year. In each case the additional controls in the regression are the DOT skills GED math, GED language, the physical attribute strength, the temperament for "dealing with people", and the workers' function "things". ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 6: The relationship between the log odds ratio of male to female employment and sensory motor and spatial aptitudes; all aptitudes multivariate regressions, controls

			1970	2012
		Sign	Coefficient	Coefficient
Sensory	Color discrimination	-	-0.115 (0.095)	-0.260** (0.102)
	Color vision	-	-0.026 (0.114)	0.028 (0.105)
	Near Acuity	-	0.062 (0.090)	-0.012 (0.072)
	Far Acuity	+	0.255** (0.105)	0.114 (0.084)
	Hearing	-	0.204 (0.139)	0.089 (0.111)
	Noise	+	0.345*** (0.106)	0.383*** (0.084)
	Tasting-smelling	-	-0.131** (0.065)	-0.001 (0.051)
	Feeling	-	-0.266*** (0.083)	-0.328*** (0.068)
Motor	Fingering	-	-0.037 (0.102)	0.118 (0.083)
	Finger Dexterity	-	-0.329** (0.133)	-0.191* (0.105)
	Handling	-	-0.244*** (0.093)	-0.142** (0.072)
	Manual dexterity	?	0.046 (0.126)	0.105 (0.129)
	Motor Co-ordination	-	0.008 (0.111)	-0.068 (0.100)
	Eye-Hand-Foot	+	-0.180** (0.090)	-0.073 (0.080)
	Clerical Perception	-	-0.192 (0.117)	-0.219** (0.109)
Spatial	Spatial skills	+	0.644*** (0.106)	0.353*** (0.102)
	Depth perception	+	0.403*** (0.124)	0.462*** (0.101)

Notes: Authors' calculations from 1970 census and 2012 American Community Survey. The estimate is from a regression of the log odds ratio of male to female employment at the occupational level on the DOT measures of the skills or aptitudes in the indicated year. In each case the additional controls in the regression are the DOT skills GED math, GED language, the physical attribute strength, the temperament for "dealing with people" , and the workers' function "things". ***, ** and * indicate statistical significance at the 10, 5, and 1 percent levels respectively.

Table 7: Predicted Duncan indices negating occupational selection on sensory, motor and spatial aptitudes, univariate results

	1970		2012	
	No Controls	With Controls	No Controls	With Controls
Actual	0.646		0.508	
Sensory				
Color discrimination	0.646***	0.641***	0.500***	0.524***
Color vision	0.647***	0.644***	0.501***	0.513***
Near Acuity	0.636***	0.635***	0.488***	0.498***
Far Acuity	0.636***	0.635***	0.497***	0.498***
Hearing	0.624***	0.646***	0.473***	0.516***
Noise	0.619***	0.621***	0.444***	0.457***
Tasting-smelling	0.642***	0.640***	0.509***	0.518***
Feeling	0.641***	0.631***	0.503***	0.481***
Motor skills				
Fingering	0.612***	0.609***	0.494***	0.493***
Finger Dexterity	0.633***	0.608***	0.505***	0.494***
Handling	0.644***	0.637***	0.508***	0.509***
Manual dexterity	0.647***	0.642***	0.517***	0.517***
Motor Co-ordination	0.651***	0.637***	0.518***	0.504***
Eye-Hand-Foot	0.627***	0.636***	0.470***	0.493***
Clerical Perception	0.619***	0.626***	0.454***	0.469***
Spatial				
Spatial skills	0.580***	0.601***	0.474***	0.487***
Depth perception	0.577***	0.591***	0.426***	0.454***

Notes: Authors' calculations from 1970 census and 2012 American Community Survey. In each case the additional controls in the regression are the DOT skills GED math, GED language, the physical attribute strength, the temperament for "dealing with people", and the workers' function "things". ***, ** and * indicate statistical significance (from the actual Duncan index) at the 10, 5, and 1 percent levels respectively.

Table 8: Predicted Duncan indices negating occupational selection on sensory, motor and spatial aptitudes, multivariate results

	1970		2012	
	No Controls	With Controls	No Controls	With Controls
Actual	0.646		0.508	
Sensory	0.601***	0.588***	0.422***	0.437***
Motor	0.576***	0.572***	0.442***	0.433***
Spatial	0.543***	0.578***	0.424***	0.456***
All	0.466***	0.497***	0.345***	0.390***

Notes: Authors' calculations from 1970 census and 2012 American Community Survey. In each case the additional controls in the prediction are the DOT skills GED math, GED language, the physical attribute strength, the temperament for "dealing with people" , and the workers' function "things". ***, ** and * indicate statistical significance (from the actual Duncan index) at the 10, 5, and 1 percent levels respectively.

Table 9: Actual and predicted Duncan indices negating occupational selection on sensory, motor and spatial aptitudes, by age

	1970			2012		
	Age 18-24	Age 25-34	Age 35-64	Age 18-24	Age 25-34	Age 35-64
Actual	0.634	0.642	0.648	0.471	0.499	0.522
Predicted	0.527***	0.515***	0.494***	0.371***	0.401***	0.392***

Notes: Authors' calculations from 1970 census and 2012 American Community Survey. Estimates are for the 470 occupations with positive employment for both men and women among young workers. In each case the additional controls in the prediction are the DOT skills GED math, GED language, the physical attribute strength, the temperament for "dealing with people", and the workers' function "things". ***, ** and * indicate statistical significance (from the actual Duncan index) at the 10, 5, and 1 percent levels respectively.

Table 10: Gender earnings gap decompositions, 2012 and 1970, negating occupational selection on sensory, motor and spatial aptitudes

	Wage differential: total	Wage differential: across occupations	Wage differential: within occupation	% across occupations
2012				
Actual (all jobs)	$12,346	$3,541	$8,805	28.7%
Actual (476 occupations)	$12,336	$3,550	$8,786	28.8%
Negating selection on:				
Sensory	$14,677	$6,504	$8,173	44.3%
Motor	$15,774	$7,599	$8,175	48.2%
Spatial	$14,421	$6,194	$8,226	43.0%
All aptitudes	$13,134	$4,676	$8,458	35.6%
STEM jobs (44 occupations)				
Actual	$3,682	$3,395	$287	92.2%
All aptitudes	$2,734	$2,393	$340	87.5%
Non-STEM jobs				
Actual	$8,654	$155	$8,499	1.8%
All aptitudes	$10,400	$2,283	$8,118	21.9%
1970				
Actual (all jobs)	$18,217	$2,958	$15,259	16.2%
Actual (476 occupations)	$18,148	$2,916	$15,232	16.1%
Negating selection on:				
Sensory	$18,262	$3,279	$14,983	18.0%
Motor	$19,071	$4,317	$14,753	22.6%
Spatial	$18,470	$3,682	$14,788	19.9%
All aptitudes	$17,085	$1,664	$15,421	9.7%
STEM jobs (44 occupations)				
Actual	$2,771	$2,583	$188	93.2%
All aptitudes	$2,181	$1,865	$315	85.5%
Non-STEM jobs				
Actual	$15,377	$333	$15,044	2.2%
All aptitudes	$14,904	-$202	$15,106	-1.4%

Notes: Authors' calculations from the 1970 census and 2012 American Community Survey. 2002 dollars. The decompositions of the gender earnings gap are based on equation (4) in the text.