

THE FACIAL MASCULINITY OF WOMEN IN SEX SEGREGATED
OCCUPATIONS

by

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Presented to the Faculty of the Graduate School of
The University of Texas at Arlington in Partial Fulfillment
of the Requirements
for the Degree of

MASTER OF ARTS IN SOCIOLOGY

THE UNIVERSITY OF TEXAS AT ARLINGTON

AUGUST 2009

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ACKNOWLEDGEMENTS

I would like to thank all my committee members: Drs. Beth Anne Shelton, Dana L. Dunn, and Raymond A. Eve.

July 17, 2009

ABSTRACT

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This purpose of the study was to bring more definition to the “problem” of occupational sex segregation, specifically why male-dominated occupations like engineering, firefighting, and the military still remain sex segregated. The study attempted to do so by integrating two findings: 1) the finding that women in male-dominated occupations are more dominant than women in female dominated occupations, and 2) the finding that facially masculine women are more dominant than facially submissive women. Facial photos of women from occupations that are $\geq 90\%$ male dominated and $\geq 90\%$ female dominated were culled from the internet and rated for their level of facial masculinity. A variety of objective facial metrics was also measured. Of the total number of measures, only rated facial masculinity and eye-mouth-eye angle (*EmE*) proved significant across occupational category. Results were

discussed in the context of both evolutionary and non-evolutionary theories of occupational sex segregation.

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CHAPTER 1

INTRODUCTION

Occupational sex segregation is the degree to which men and women are concentrated in occupations that are dominated by one sex (Renzetti & Curran, 2003). Though occupational sex segregation itself has declined markedly since the 1970's¹ (Cotter et al., 1995), certain occupations like engineering, firefighting, and the military still remain sex segregated (National Science Foundation, 2007; U.S. Census, 2000; U.S. Department of Defense, 2007). The question is *why?*

1.1 Supply-side explanations

This class of explanation focuses on the supply side of the equation, i.e. worker's preferences and actions (Reskin, 1993)

1.1.1 Neoclassical/human capital theory

Neoclassical/human capital theory trades on the idea of human capital. Women are thought to have less of it than men, e.g. less education², less experience, and less work productivity (Anker, 1998). A factor that may account for some of the difference is the additional familial and childcare responsibilities women have. The added responsibility can lead women to sustain higher rates of intermittent and/or truncated

¹ With the 1970's as the watershed decade (Jacobs, 1989), the rate of occupational desegregation has -since the 1980's- declined (Cotter et al., 1995) with occupational distributions by sex from the 80's onward being overall -at least up until the year 2000- relatively stable (Gabriel & Schmitz, 2007).

² As Anker (1998) notes, this supposition is questionable at best as the education levels of women in many countries are now on par with men.

labor market participation effectively hampering their ability to gain experience in the market.

Women are therefore more likely to have less work experience than men and by extension less “capital” (Anker, 1998). Women are “cognizant of this” and purportedly shift their occupational ambition away from occupations that demand more capital, i.e. higher status, higher paying, occupations. The end result is that women segregate into lower status, lower paying, occupations creating -in the process- a lower supply of women to compete for and fill the higher status, higher paying, occupations.

1.1.2 Gender-role socialization

This point of view maintains that differences in socialization lead women to gravitate more towards “sex-appropriate” occupations and less towards “sex-inappropriate” ones. Not only does it lead them to gravitate towards “sex-appropriate” occupations but it leads them to prefer the working conditions associated with them. More generally, it also leads them to be more receptive about learning about “sex-appropriate” occupations and more receptive to learning the skill sets associated with them (Reskin, 1993). Socialization in effect leads women to preferentially select themselves for these occupations thus skewing the supply of available women towards them and away from the more competitive higher status, higher paying jobs - segregating them thus in the process.

1.1.3 Status attainment theory (SAT)

SAT largely attributes the pattern of occupational sex segregation observed today to the behavior, values, aspirations, attitudes, and sex-role expectations of women

(Strober, 1984). Women are thought to self-select themselves into occupations that are more consistent and more compatible with their dispositions along these lines, i.e. female-dominated occupations.

Given that female-dominated occupations on average carry lower status and lower pay than male-dominated occupations (Strober, 1984), the suggestion is that women are not only determine their occupational segregation but also their occupational inequality.

1.1.4 Evolved sex differences

This point of view explains occupational sex segregation as largely a function of the notion that men are more likely to have the evolved temperament and cognitive capacity³ to be successful in male-dominated occupations⁴ as male-dominated occupations are thought to leverage characteristics like competitiveness, dominance, risk taking, status-seeking behavior, mathematical ability, spatial ability, and physical strength; all characteristics where men on average exceed women (e.g., Browne, 2002; Mazur & Booth, 1998; Byrnes et al., 1999; Kimura, 1999; Pheasant, 1983)⁵.

³ These are but statistical differences. Some women exceed some men on these dimensions just as some men exceed some women on other dimensions, e.g., nurturance, expressiveness, and warmth, making some men in effect more suitable for female-dominated occupations like nursing, childcare, or preschool education than some women.

⁴ People more suited to these occupations are thought to self-select themselves in the sense of seeking out these occupations and proving to be the most viable and successful at them. This is not to say, given the logic, that occupational desegregation is moribund. The government in theory could institute measures to more fully potentiate its ability to identify viable and -as of yet- unidentified candidates for these occupations, e.g. people who have not yet self-identified as compatible with these occupations or people who are for example vocationally misplaced etc. To use the wage gap as an example, it is markedly less pronounced in Australia than it is in the U.S. The economy there is structurally different in that its wage determination is centralized, its workforce more unionized, and it unlike the U.S. has comparable worth policies (Browne, 1998).

⁵ Not unexpectedly, these characteristics all depend on testosterone for their expression e.g. competitiveness (Mazur & Booth, 1998; Archer, 2006), dominance⁵ (Mazur & Booth, 1998; Grant & France, 2001), risk taking and status-seeking behavior (e.g. Josephs et al., 2003; Archer, 2006), spatial ability⁵ (Kimura, 1999), and physical strength (e.g. Evans, 2004).

The suggestion is that success in these occupations is more likely the more masculine you are. That is, the more competitive, dominant, risk-taking, status seeking, and/or physically stronger you are –and/or the more spatial and mathematical ability you have- the more likely you will be successful in these occupations.

Occupations that are more spatially demanding in fact do have lower concentrations of women (Browne, 2006), e.g., engineering (13.5%), astronomy/physics (13.9%), as do occupations that are more physically demanding, e.g., construction (3.5%), firefighting (3.6%), and occupations where risk-taking, status-seeking, or occupations dominance are at a premium, e.g., chief executive positions (18.7%) or the military (13.75%) (U.S. Department of Defense, 2007).

Occupational sex segregation seems better accounted for therefore by the extent to which each occupation involves physical and cognitive abilities, and/or temperaments or behaviors that are testosterone mediated, e.g. competitiveness (Mazur & Booth, 1998; Archer, 2006), dominance⁶ (Mazur & Booth, 1998; Grant & France, 2001), risk taking and status-seeking behavior (e.g. Josephs et al., 2003; Archer, 2006), spatial ability⁷ (Kimura, 1999), and physical strength (e.g. Evans, 2004).

This explanation on the whole is simpler and yields a list of occupations that are not only currently sex segregated but ones that have been *historically so*. As Browne (2002) notes, the level of segregation in these occupations has changed little -if at all- in

⁶ Grant & France (2001) found that women with high testosterone levels were more dominant than women with lower levels

⁷ Women with the highest testosterone (T) levels tended to have the highest levels of performance on spatial tasks. In men, those in the low normal range have the highest level of performance. Accordingly, women with high T are the closest in T levels to men in the low-normal range (Gouchie & Kimura, 1991).

the last 30 years, unlike occupations such as dentistry, law, or medicine, which have largely since desegregated (see National Center for Education Statistics, 2004).

Given the logic, it would be reasonable to expect then that females who are successful in male-dominated occupations are probably just that—more masculine. This indeed seems to be the case. Women in male-dominated occupations—be they white or blue-collar occupations—, are generally more psychologically masculine^{8,9,10} than women in female dominated occupations (e.g. Mandelbaum, 1981; Moulliet, 1979; Williams & McCullers, 1983), more dominant (e.g., Mazen & Lemkau, 1990¹¹; Mandelbaum, 1981), more competitive, more assertive, more instrumental with a higher capacity for status (Mazen & Lemkau, 1990); and when compared to the general female college population more instrumental (Jagacinski, 1987), more achievement oriented and more dominant (Brown & Joslin, 1995).

Additionally, women who fit the nontraditional category in terms of either career-home commitment, field of study in college or graduate school, or field of prospective or current employment tended on paper-pencil tests tended to manifest as masculine (Hennig, 1970; Segal, 1980), more dominant (Segal, 1980; O'Connell, 1980),

⁸ Masculinity is also analogous, both conceptually (Wiggins and Holzmuller, 1981), and psychometrically to dominance (Wiggins & Broughton, 1985), the latter being the case when masculinity is measured by the (BSRI) Bem Sex Role Inventory (Wiggins and Holzmuller, 1981), and less directly when measured by instruments like the Spence *EPAQ* inventory. The Spence *EPAQ* masculinity scale correlates at $r = .69$ with the Ambitious-Dominant dimension of the Interpersonal Adjective Scale (Wiggins & Broughton, 1985)

⁹ Masculine personality traits in men and women are positively correlated, both pre- and postnatally, with testosterone (Mazur & Booth, 1998; Al-Ayadhi, 2004; Baucom, Besch, & Callahan, 1985; Grant & France, 2001; Udry & Talbert, 1988). Accordingly, women in more male-dominated occupations like professional, managerial, and technical jobs have higher serum levels of testosterone than clerical workers or housewives (Purifoy & Koopmans, 1979)

¹⁰ Lastly, in women, masculinity is a positive predictor of career achievement even when controlling for education (Wong, Kettlewell, & Sproule, 1985).

¹¹ This study included women from male-dominated blue-collar occupations, i.e. women police officers and industrial craftswomen.

and risk-taking in nature (Douce, 1978), with a high need for status (Segal, 1980; O’Connell, 1980) and achievement (Hennig, 1970; Mandelbaum, 1981; O’Connell, 1980; Segal, 1980).

1.2 Demand-side explanations

This class of explanation focuses on the demand side of the equation, i.e. on employer preferences and practices.

1.2.1 Discrimination theory (DT)

Under DT, employers make hiring decisions based on assumptions they hold about the sexes of the people they hire (Reskin & Hartmann, 1986). The assumptions themselves are not necessarily valid but they are held nonetheless and employers use them to discriminate between men and women in the hiring process. To the extent that these assumptions segregate women, they contribute to the perpetuation of occupational sex segregation. Examples of these assumptions include beliefs about the capabilities, tendencies, and overall disposition of women and how these elements play into what occupations employers think women may or may not be suited for- in terms of their viability within these occupations and their chances of success at them.

1.2.2 Statistical discrimination theory (SDT)

SDT is predicated on 1) the employer bring a “rational” actor, 2) on statistical differences in productivity, skills, experiences etc. between men and women, and 3) on the assumption that high search and information costs are required to properly identify and select whom to hire or promote (Anker, 1998).

By the first assumption, the employer operates with the overriding imperative of always maximizing profit and reducing cost. As long therefore as differences in productivity, skills, experiences etc. between men and women do not exceed the differential costs of employing them (Anker, 1998), it is rational for the employer to discriminate against women, i.e. default against the sex that statistically provides the lowest chance of maximizing profit and minimizing cost.

Since the employer is relying on statistical differences, a substantial number of competent and able women, i.e. the ones that perform better or comparably with most men, are not hired. This imbalance in demand ultimately serves to segregate men in these occupations from women.

1.2.3 Neoclassical/human capital theory

Neoclassical/human capital theory works on both the demand and supply sides. Like the supply side explanation, the theory trades on human capital but as evaluated instead by the employer not the worker (Anker, 1998). Many of the same considerations therefore apply. One of them deals with the level of education across sex. Occupations that require a high level of education are more often offered to men as they are assumed on average to be more educated than women.

Not only are men thought to have more education than women, but they are also assumed to be less expensive to employ. They for instance have lower absenteeism rates than women and lower rates of tardiness (Anker, 1998). They also have lower turnover rates. All the above is assumed to stem from the increased family responsibilities of women, i.e. caring for children, spouses, or other family members. These

responsibilities are thought to make women more likely to miss work, be late to it, and/or quit it altogether.

Increased employment cost may also be incurred through the provision of daycare facilities. Women sometimes cannot rely on or afford to pay others to take care of their children. All these factors conspire to make employers less likely to hire women, thus in a sense “channeling” or segregating them into more accommodating occupations –jobs that often don’t provide as much material reward or status, i.e. female dominated jobs.

1.2.4 Institutional inertia

This factor deals with precedents, i.e. which sex has historically held certain occupations and which sex currently dominates them (Preston, 1999). An example would be secretarial jobs as they historically have -and up to this day- been dominated by women. When these positions are being filled, the sex hired usually conforms to precedent. That is, the individual hired to fill an open secretarial position is more likely to be a women both by virtue of precedent and the fact women currently overwhelmingly hold those positions. The yielded effect being that female-dominated jobs stay female-dominated and, by virtue of the numbers of women routed into these occupations, segregate women away from higher paying jobs where males predominate.

1.2.5 Patriarchy¹²

This view relies on two assumptions. Men by virtue of the occupational choices they make and the hiring positions they hold segregate or displace women into

¹² As it functions within the constraints of race and class

particular jobs or occupations (Strober, 1984). Strober argues thus that occupational sex segregation occurs largely because men dominate the reins of power in the labor market and by virtue of that control have preferential access to its rewards. The other assumption speaks to the fact that men are concerned with maximizing their economic gain. Therefore, if a man realizes that better prospects lie elsewhere other than his current job or occupation, he vacates it “passing it down” in effect to women. Given the passed down job is invariably inferior, in terms of wages, hours, and working conditions, women are relegated to them and hence segregate into them. This not only perpetuates occupational sex segregation in the labor market but occupational inequality as well.

1.3 Purpose

This purpose of the study was to bring more definition to the “problem” of occupational sex segregation, specifically why male-dominated occupations like engineering, firefighting, and the military still remain sex segregated (National Science Foundation, 2007; U.S. Census, 2000; U.S. Department of Defense, 2007), despite the passage of anti-discrimination laws, the increased participation of women in the labor force, and the greater participation of women in higher education (Wooton, 1997).

The study attempted to do so by integrating two findings: 1) the finding that women in male-dominated occupations¹³ are more dominant than women in female

¹³ Occupations that are referred to as male-typical (Mazen & Lemkau, 1990) nontraditional (Mandelbaum, 1981), or [female] atypical (Lemkau, 1983) have been subsumed under the term ‘male-dominated’- as these terms are, more or less, synonymous in meaning.

dominated occupations (e.g., Mazen & Lemkau, 1990¹⁴; Mandelbaum, 1981)¹⁵, and 2) the finding that facially masculine women are more dominant than facially submissive women (e.g. Berry & Brownlow, 1989; Berry, 1990; Berry, 1991; Cherulnik et al., 1990)

From evidence linking facial masculinity (A) with dominance (B), and evidence linking dominance (B) with women in male-dominated occupations (C), one should expect to see a higher incidence of facial masculinity (A) among women in male dominated occupations (C) -- (A→B and B→C, A → C).

Accordingly, the study asked the question: Are women from male-dominated occupations more facially masculine than women from female-dominated occupations?

1.4 What is facial masculinity?

Facial masculinity is simply how masculine a face looks. It is a configural perception, a gestalt, a consolidation of the following¹⁶: a square chin, protruding brow ridges, square jaws, and broad cheekbones (e.g. Enlow & Hans, 1996; Hennessy et al., 2005; Rosas & Bastir, 2002).

Facial femininity is its opposite quality and consists of a V-shaped face, enlarged eyes, a small & concave nose, full projecting lips, and high eyebrows (e.g. Cunningham, 1986; Braun et al, 2001).

¹⁴ This study included women from male-dominated blue-collar occupations, i.e. women police officers and industrial craftswomen.

¹⁵ Women in addition who fit the nontraditional category in terms of either career-home commitment, field of study in college or graduate school, or field of prospective or current employment tended in “stand-a-lone” personality testing to manifest as dominant (Segal, 1980; O’Connell, 1980), the implicit population of comparison there being the scoring norms for the larger female population

¹⁶ In different combinations and/or degrees

As noted earlier, facial masculinity is essentially facial dominance¹⁷. Objectively, they are -if not identical- virtually indistinguishable. They are though conceptually different. Facial dominance is the degree to which a person is *perceived* from the face to be *dominant*, assertive and a leader (Mueller & Mazur, 1997) while facial masculinity now as before is how masculine a face looks.

One lies along a *masculinity-femininity* dimension, the other along a *dominance-submissiveness* dimension. Though both facial *submissiveness* and facial *femininity* overlap, they are distinct qualities. Facial submissiveness consists of a round face, large eyes, smallish nose, and high eyebrows (e.g. Enlow & Hans, 1996; Hennessy et al., 2005; Rosas & Bastir, 2002; Mueller & Mazur, 1997). It is essentially a “baby faced” or neotenous appearance. It is the degree to which a person is perceived as submissive, unassertive, and a follower (Mueller & Mazur, 1997).

Facial femininity is superordinate to and -more or less- subsumes facial submissiveness. The converse however does not hold. A facially submissive face is not necessarily feminine.

1.4.1 Sexual dimorphism

Though facial masculinity is found in both sexes, it is not distributed equally. It is “by definition” more pronounced in males than females¹⁸. The differences though are only statistical. That is, some women look more masculine than some men. The proportion of women who are facially masculine however does not *appear* to equal the

¹⁷As such, the terms hereafter are used interchangeably.

proportion of men who are facially feminine¹⁹. There is apparently a somewhat higher proportion overall of facially masculine women among women than facially feminine men among men (Valenzano et al., 2006)²⁰. Further, a lower proportion of men are more facially masculine than the most facially masculine women and conversely a higher proportion of women are more facially feminine than the most facially feminine men. The facial masculinity-facial femininity distribution in women is also evidently more variable.

1.4.2 Development

Androgen exposure is the proximate cause behind the development of facial masculinity. Simply stated, exposure to higher levels of testosterone, pre- and perinatally, prime the body towards a more masculine organization (Mazur & Booth, 1998). Part of that masculinization involves the distribution of androgen receptors throughout the skull and facial area. Later around puberty, a high testosterone-to-estrogen ratio *activates* these receptors. The net effect²¹ is the projection of the brow ridge, the lateral growth of the lower jaw, chin, and cheekbones, and the lengthening of the lower face (Enlow & Hans, 1996; Thornhill & Gangestad, 1996). Conversely, a high estrogen-to-testosterone ratio inhibits the growth of these features yielding a more submissive or feminine appearance (see Thornhill & Moller, 1997).

¹⁸ Admittedly, relative to men facial masculinity in women is attenuated. Therefore, women who are high in facial masculinity generally still keep a feminine appearance. Accordingly, facial masculinity in women is judged only relative to other women.

¹⁹ Geometric morphometrics, a method for multivariate statistical analysis of shape, was used to measure geometric facial sexual dimorphism of male and female face profiles.

²⁰ The finding should be interpreted with caution, as the sample was apparently self-selected.

²¹ In different combinations and degrees

1.4.3 Dominance

Facial masculinity is thought to signal an individual's dominance^{22,23} potential or his/her potential to act "...overtly so as to change the views and actions of another" "...and [all the while] being unwilling to change one's own attitudes or behavior merely at the instigation of others (i.e. without explanation)" (Fiske, 1971)²⁴ .

Consistent with the definition, facial masculinity correlates positively with dominance and traits that subsume it (or are subsumed by it), e.g. social potency, masculinity, assertiveness, competitiveness, and power (e.g. Berry & Brownlow, 1989; Berry, 1990; Berry, 1991; Cherulnik et al., 1990; Mazur & Booth, 1998)²⁵. Facial masculinity also predicts status attainment or *actual dominance*. Relative to their subdominant counterparts, facially masculine men and women are more likely to achieve higher levels of status (e.g. Keating, 1985; Cherulnik et al., 1990; Mazur, Mazur, & Keating, 1984)²⁶.

A prominent illustration of this status-enhancing effect was observed in a classic series of studies²⁷ by Allan Mazur and his colleagues. Mueller and Mazur (1997) showed that facial masculinity confers an advantage with respect to rank attainment in the military. Men judged as facially dominant ultimately reached higher levels of

²² Terms that dominance can be likened to include: powerful, authoritative, masterful, ascendant and high in control (Sadalla, 1987)

²³ Testosterone levels in women are positively associated with dominance (Cashdan, 1995; Grant & France, 2001)

²⁴ As cited in Grant (1998)

²⁵ As was the case with facial masculinity, there is a sexually dimorphic pattern to the quality. Men are more dominant than women (Mazur & Booth, 1998) but as was the case earlier, the difference again is only statistical, i.e. there are some women who are more dominant than some men.

²⁶ This extension flows logically and stems from the necessity of having to behave dominantly to achieve actual dominance or *status*.

²⁷ Mazur et al. (1984), Mazur & Mueller (1996), Mueller & Mazur (1997)

military rank than their comparably qualified “subdominant” counterparts²⁸. The question is how and -more importantly- why?

1.4.4 Facial masculinity and dominance under the evolutionary view

According to the evolutionary account, the two traits correlate because of the *handicap principle* and *honest signaling theory*. The handicap principle is an idea proposed by the Israeli biologist Amotz Zahavi. It deals with the way animals, including humans *signal* their evolutionary fitness²⁹ to members of their own species (Bergstrom, 2002). The handicap principle is predicated on the concept of the biological signal.

A biological *signal*, according to Johnstone & Grafen (1993), is any action and/or physical structure that increases the fitness of the signaling organism. Fitness is increased³⁰ -however indirect and small the effect -by an induced change in the behavior of the *receiver*, e.g. a mother’s response to a crying baby, people running out of a theater after somebody yells “Fire!” Accordingly, a *signal response* is any change in the behavior of the receiver. An *honest signal* is simply one that conveys accurate information.

1.4.4.1 The handicap principle

As detailed earlier, testosterone levels mediate the development of facial masculinity. Facial masculinity is in effect a testosterone “marker.” A by-product of testosterone exposure is the suppression of the immune system (Folstad & Karter,

²⁸ Using a similar design, no studies to date however have incorporated women

²⁹ Fitness simply refers to the proportion of the individual's genes in all the genes of the next generation. It bears directly on reproductive success. All things being equal, the more you reproduce the more your genes are represented in the next generation.

³⁰ What is increased in effect is its average dynamic probability to survive to reproductive age

1992). The suppression constitutes a cost or *handicap*, i.e. a decrease in disease resistance. Individuals that sustain good health despite the handicap tend to be individuals of higher quality³¹ (Thornhill & Gangestad, 1993).

Accordingly, facial masculinity in men correlates positively with both rated and actual health (e.g. Zebrowitz & Rhodes, 2004; Rhodes et al., 2003), correlates negatively with antibiotic use and negatively with the incidence & duration of respiratory disease (Thornhill & Gangestad, 2006). This pattern relative to women however is not expressed. The only conclusive indicator, i.e. the incidence & duration of respiratory disease, *positively* correlated with facial masculinity in women. In other words, the same effect did not evidence³². The question is why?

Testosterone -in addition to its handicapping effect- appears to potentiate the ability to engage in male-to-male competition (Thornhill & Gangestad, 1999). That is, it appears involved both organizationally (prenatally) and activationally (postnatally) in increasing the likelihood of certain behaviors, e.g. competitiveness, dominance, risk taking and status seeking behaviors (Cashdan, 2003; Mazur & Booth, 1998; Apicella, et al., 2008; Grant & France, 2001; Josephs et al., 2003; Archer, 2006), all behaviors that come into play when males compete.

The trade-off for women when it comes to the potentiation of these behaviors is the assumption of an additional handicap: lower fertility. Women with higher

³¹ Individuals of lower quality cannot easily sustain the cost and therefore run a higher risk for ill health and disease. Relative to signalers of comparable quality and especially signalers of higher quality, this has the mean effect of reducing their fitness.

³² As before, it is important to emphasize the statistical nature of the finding and note that there are facially masculine women who probably sustain the handicap and are, comparatively speaking, in better condition than the average.

testosterone levels tend to be less fertile than women with lower levels³³ (Steinberger, Smith, and Rodriguez-Rigau, 1981). This leaves women with higher testosterone levels at a reproductive disadvantage. That is, relative to women with lower testosterone levels they are less able and by extension less likely to reproduce. This effectively limits their frequency in the population. A lower proportion of dominant women relative to such men therefore would not be unexpected. It dovetails with data indicating that men tend on average to be more competitive, risk taking, and status-seeking than women (e.g., Browne, 2002; Byrnes et al., 1999; Buss, 2007), and more facially masculine.

1.4.4.2 Honest signaling theory (HST)

According to Honest Signaling Theory, signals are reliably honest³⁴ if: 1) the signal is costly, and 2) the cost of the signal is proportionately higher³⁵ for individuals of *lower* quality³⁶ (Johnstone, 1995).

Using competence as an index of quality, Mueller and Mazur (1997) demonstrated that if facially dominant men (army cadets) did not meet a minimum standard of competence they were rank promoted at significantly lower rates than facially dominant army cadets who either met or exceeded the standard. The more qualified cadets in effect achieved higher military ranks than their less competent counterparts.

³³ To compound the effect these women have a higher career orientation and less reproductive ambition. This is ostensibly an effect of potentiating the suite of behaviors already described (Deady et al., 2006).

³⁴ Or accurate

³⁵ Or conversely, proportionately lower for individuals of higher quality

³⁶ Quality in the sense of being able to successfully compete in environments where competitiveness, dominance, status-seeking are at a premium while, all the while, remaining more viable reproductively than non-signalers of comparable quality. An individual of low quality denotes a person with a low potential to successfully express the aforementioned traits and likely a person with a lower relative fitness relative to non-signalers of the same quality.

Status in the military equates with rank, the more rank you have the higher your status. Given that status in male dominance hierarchies correlates with reproductive fitness (Betzig, 1993), we would expect facially dominant cadets who achieved higher status by virtue of their higher quality to father more children to the age of sexual maturity than their lower ranked (lower quality) counterparts. This is exactly what was observed in Mueller and Mazur (1997). The advantage conferred by facial dominance is dependent upon meeting a minimum standard of quality. The suggestion is when a signaler “over-signals,” i.e. signals a level of quality he does not possess, a significant fitness cost is imposed, i.e. reduced fitness in men by correlation with reduced status.

This cost constitutes a *natural selection* pressure against “dishonest” signalers. Fundamentally, dishonest signalers fare worse than non-signalers of comparable quality. Conversely, honest signalers fare better than non-signalers of comparable quality (Mueller & Mazur, 1997). Ultimately, the fitness cost to the dishonest signaler is what insures the honesty and stability of the signal. Unlike individuals of higher quality, lower quality individuals simply cannot assume the handicap without sustaining a significant loss in fitness. The marginal cost is higher thus for individuals of lower quality, so high that they cannot *both* maintain the cost and *not* sustain a significant loss in fitness.

The logic is analogous to Veblen’s (1899) concept of conspicuous consumption. In the analogy, extravagant displays of wealth, e.g. yachts, expensive jewelry, mansions etc., function as handicaps. Yachts, expensive jewelry, mansions etc. are costly products. Unlike individuals of poorer wealth, individual of greater wealth are more

likely to sustain these costs without a significant loss in “financial fitness”, especially as it regards the long term. In the same sense then that conspicuous consumption is an honest advertisement of wealth; facial dominance *is* an honest advertisement of quality.

Revisiting the handicap issue³⁷ in women- women who can tolerate the testosterone-handicap, i.e. its negative effect on both fertility and the immune system, are according to HST more likely to be women of higher quality or -in effect- women who can more effectively compete in environments where competitiveness, dominance, status-seeking are at a premium while, all the while, still remaining *viable* reproductively.

In the Mazur studies, the quality test used -the *General Order of Merit (GOM)* - is a composite measure consisting of academic grades, ratings of leadership & military aptitude, and physical education grades³⁸ (Mueller & Mazur, 1997). Again, only individuals who met or exceeded the “quality threshold”³⁹ benefited from being facially dominant. Validating signal quality in other words acts to “control” the number of “over-signalers” in the population. This in turn insures the integrity of the signal, i.e. keeps it honest.

³⁷ Though women on average have 1/7 to 1/5 times less testosterone than men do (Nelson, 2000) [as cited in Colarelli et al., 2006], facially masculine women apparently have enough testosterone to induce an immuno-suppressant effect (Thornhill & Gangestad, 2006)

³⁸ The GOM is designed to measure cognitive, social, and athletic skills. Along with dominance, a threshold level of the skill set is vital to the achievement of high status. Without it, the exertion of dominance and ultimately the achievement of high status becomes incoherent (Mueller & Mazur, 1997)

³⁹ The operating assumption is that women in male-dominated occupations have, in addition to being dominant, at least a threshold level of the necessary cognitive and social skills, i.e. they are -by virtue of their pursuit and employment in these occupations- of ‘higher quality’.

1.4.4.3 Implications

If one proposes an evolutionary account of facial dominance then one would expect the perception of facial dominance to be “hard wired.” If that were not the case, we would not expect infants and small children to reliably perceive it. They are not yet - after all- coherently socialized. Infants and small children however can AND do just that. They reliably distinguish dominant faces from submissive faces (Kramer et al., 1995; Gross, 1997; Montepare & Zebrowitz et al. 1989). They can also differentiate differences in degree, i.e. whether one face is more or less dominant than another. Children characterize such faces as belonging to people who “...*look like they are going to fight the most and get what they want...*” (Keating & Bai, 1986).

Additionally, if the perception of facial were “hard wired” we would also expect its perception to be cross-culturally reliable. It is in fact so. As stated earlier, people from different cultures make out dominant faces, and do so reliably (Keating et al. 1981; Keating, Mazur, & Segall, 1981).

The innate nature of the facial masculinity perception is also suggested by electrophysiological and imaging evidence. For example, Cellerino et al. (2007) using scalp event-related potentials (ERPs) have been able to correlate the processing and perception of facial masculinity with the right parieto-temporal region. Zink et al. (2008) further revealed using functional magnetic resonance imaging (fMRI) that brain structures like the bilateral occipital/parietal cortex, ventral striatum, parahippocampal cortex, and dorsal lateral prefrontal cortex (DLPFC) are differentially activated when

processing people of higher status⁴⁰. Viewing people of higher status elicits a greater activation. Viewing people of lower status elicits less. People apparently devote more perceptual and attentional resources when processing people that are more dominant. In conjunction with the reliability of facial masculinity ratings then, this suggests that the perception of -and response to- facial masculinity may have a hard-wired basis (Mueller & Mazur, 1997).

1.4.5 Facial masculinity and dominance under an alternative view

An alternative account behind the association between facial masculinity and dominance is Socialization/Social Expectancy Theory (Langlois et al. 2000).

Socialization/Social expectancy theory (S/SET) have at their core two assumptions: 1) Life experiences and cultural norms influence the behavior of signalers and signal receivers; and 2) Social stereotypes *generate* their own reality (see Langlois et al., 2000).

From these assumptions, the following causal mechanism is derived. Facial masculinity sets up expectations about the behavior and traits of masculine and sub-masculine signalers. Perceivers operate on these expectations and in turn judge and treat masculine and sub-masculine signalers differently. Differential judgments and treatments in turn prime the development of differential behaviors and traits in the signalers. Facially masculine and sub-masculine signalers then internalize the differential judgments and treatments and in turn produce differential behaviors and self-perceptions.

⁴⁰ Higher status equates to a higher level of *actual dominance*

1.5 Restatement of purpose

The study seizes upon the finding that women in male-dominated occupations are more dominant than women in female-dominated occupations. Given that we know that facial masculinity and dominance are statistically dependent⁴¹ then comparatively speaking women in male-dominated occupations should be more facially masculine than women in female dominated occupations. This study applied the handicap principle and honest signaling theory to test whether women from male-dominated occupations, because they are more behaviorally masculine and dominant, are physiognomically more male-like (or more facially masculine) than women from female-dominated occupations.

As stated previously, the study attempted to bring more definition to the “problem” of occupational segregation, specifically why male-dominated occupations like engineering, firefighting, and the military still remain sex segregated (National Science Foundation, 2007; U.S. Census, 2000; U.S. Department of Defense, 2007), despite the passage of anti-discrimination laws, the increased participation of women in the labor force, and the substantial gains made by women in higher education (Wootton, 1997).

⁴¹ Given that both facial masculinity and dominance are mediated by testosterone (Enlow & Hans, 1996; Mazur & Booth, 1998), they as predicted by the androgen hypothesis positively correlate with each other, i.e. they are statistically dependent.

1.6 Synopsis of facial measures

1.6.1 Facial masculinity

Facial masculinity was measured both subjectively and objectively in the study

1.6.1.1 Facial masculinity ratings

Facial masculinity ratings of photo stimuli were collected using a 5 pt Likert type scale (1 = not masculine ↔ 5=very masculine). This mode of measurement has proven reliable⁴² in a number of studies, (e.g., Koehler et al., 2004; Boothroyd et al., 2005; Fink et al., 2007), see Methods chapter.

1.6.1.2 Facial metrics

Facial masculinity was assessed objectively using measures that are based in part on Penton-Voak et al. (2001) and Gangestad & Thornhill (2003). The measures selected were all facial proportions and consisted of the following dimensions: jaw-to-cheek breadth, eyes-to-face area, lower face-to-face height, face height-to-width, and eye-mouth-eye angle (*EmE*)⁴³.

The more masculine the face is the greater are the jaw-to-cheek breadth, lower face-to-face height, and face height-to-width, and accordingly the smaller are the eyes-to-face area and the eye-mouth-eye angle (*EmE*), see the Methods chapter.

⁴² Cronbach's Coefficient Alpha's (Interrater Reliability) of $\geq .80$

⁴³ The vertex created by connecting the center of each pupil with the center of the mouth, see Methods chapter.

1.7 Hypotheses

Hypothesis 1

Women from male-dominated occupations will rate as more facially masculine than women from female-dominated occupations.

Hypothesis 2

Women from male-dominated occupations will have greater jaw breadth proportions than women from female-dominated occupations.

Hypothesis 3

Women from male-dominated occupations will have greater lower face height proportions than women from female-dominated occupations.

Hypothesis 4

Women from male-dominated occupations will have greater (total) face height-to-width proportions than women from female-dominated occupations.

Hypothesis 5

Women from male-dominated occupations will have smaller eye area proportions than women from female-dominated occupations.

Hypothesis 6

Women from male-dominated occupations will have smaller EmE angles than women from female-dominated occupations.

CHAPTER 2

METHODS

2.1 Phase I

2.1.1 Materials

2.1.1.1 Photo stimuli.

A total of 128 photos were used, i.e. 64 *mDom* pictures & 64 *fDom* pictures. The occupational group (*m/f dom*) categories consisted respectively of “head shots” of women from occupations that are $\geq 90\%$ male dominated (the *mDom* category) and “head shots” of women from occupations $\geq 90\%$ female dominated (the *fDom* category)⁴⁴.

Unless otherwise specified, pictures were culled primarily⁴⁵ from the Google Image Search index⁴⁶. Photos had to satisfy 4 conditions: 1) they had to incorporate a frontal view of the head; 2) the faces of the pictured had to bisect at the upper lip crease at a +/- 3% tolerance from dead center^{47,48}; 3) the photo had to satisfy the Google '*Extra Large images*' search option⁴⁹; and 4) the pictured identity had to be confirmable⁵⁰.

⁴⁴ Which occupations were included were functions of the online availability of frontal view headshots and the condition that the occupation be $\geq 90\%$ sex dominated

⁴⁵ Except for the '*Military Officer*' occupational category

⁴⁶ Google Image Search is a database which indexes billions of images

⁴⁷ Using the *bisect* feature of the *ImageJ 1.40g 'Straight Line'* tool (Rasband, 1997-2007)

⁴⁸ This controls for measurement confounds related to the rotation of the head around its vertical axis

⁴⁹ This insures that the images returned are of higher rather than lower quality

⁵⁰ This serves the dual purpose of ensuring that age can be tracked or tabulated as a covariate given knowledge of identity. If not apparent at discovery, age was determined through tracking sites such as US Search (2008) or Intelius (2008)

For example, using the search term "firefighter" only 'Extra Large' front view head shots (or the equivalent) were considered. Photos were collected via the link to the originating site. If the firefighter photo was female then that picture was collected along with any other eligible photo of a female firefighter on the site⁵¹.

The search process proceeded in the order of the identified results and, as such, the composition of the sample was a function of the order generated by the Google Image search algorithm. The selection parameters used were not expected to yield any systematic bias in the photo sample.

2.1.1.2 Additional data

In addition to the pictures, age and race information were also collected, as both age and race confound the measurement of facial masculinity. Age for instance decreases the facial femininity of women's faces⁵² (see Thornhill & Gangestad, 1999)⁵³. Therefore, age served as a control⁵⁴.

Race information may also be significant in the sense that it may also play a role in the perception of dominance. White perceivers for example tend to rate African-American targets as more powerful and dominant (Zebrowitz et al., 1993) and more threatening than other racial groups (Mendes et al., 2002).

⁵¹ If the photo identified was male then eligible photos of female firefighters were collected via link to the originating site.

⁵² For reasons not yet understood, the ratio of estrogen to androgen production in females falls as they age leading to a less feminized facial appearance (see Thornhill & Gangestad, 1999).

Note: More generally, masculine faces appear older than feminine faces because of the association between facial femininity and "babyfacedness".

⁵³ Indirect evidence also supports the finding. All things being equal, increased age is associated with higher status and, by extension, potentially higher levels of facial masculinity (Sidanius & Pratto, 2001)

⁵⁴ Age at the time of the photo is the imperative not current age. If "photographic age" cannot be determined then either current age or extrapolated age was substituted, e.g. age as of last year she was still CEO vs. age after the fact

Smiling⁵⁵ was also controlled as it affects the perception of dominance. All things being equal, not smiling makes one appear more dominant (Keating et al., 1981). Wearing glasses appears to affect the perception of dominance as well. Wearing them, at least among military officers, makes for a less dominant appearance (Mazur & Mueller, 1996). This study operated on that assumption.

Lastly, the presence of visible earrings was controlled as it was found to correlate negatively with both occupational group and rated facial masculinity.

2.1.1.3 *mDom* collection

Sixty-four facial photographs of women working in male-dominated occupations were used. The *mDom* collection drew from the following occupational orders, all of which are $\geq 90\%$ male dominated: *Fortune 500* (1997-2008) & *Fortune Global 500 CEO's* (2005-2008): $\geq 97.6\%$ male dominated (Catalyst, 1997-2000, 2002, 2005⁵⁶-2007; *Fortune 500*, 2008; *Fortune Global 500*, 2008).

A total of thirty female *Fortune 500* & *Fortune Global 500* CEO's held office between 1997 & 2008. Using their names as search terms, their photographs were culled from the Google Image Search index using the procedure outlined earlier⁵⁷. Of the thirty CEO's, the photographs of nineteen were located. Sixteen of the nineteen were randomly selected and included in the study.

⁵⁵ Smiling as a factor consisted of 2 levels: not smiling and smiling

⁵⁶ The 2005 report includes CEO stats from 2001 & 2003-2004

⁵⁷ With the obvious exception that the searches were of specific people vs. occupational orders

Military officers⁵⁸ (U.S. Department of Defense, 2007^e): 1) Marine Corps officers (Brig. General to General): 97% male dominated; 2) Air Force officers (Brig. General to General): 94.5% male dominated; 3) Navy officers (Rear Admiral to Admiral): 95.7% male dominated; 4) Army officers (Brig. General to General): 97% male dominated.

Eligible photos were culled from the following service websites (U.S. Department of Defense, 2007^{a, b, c, d}), and if necessary from *Google Image Search*. Of the thirty-three photos culled, sixteen were randomly selected and included in the study. Tenured or tenure track engineering faculty⁵⁹: 1) Mining engineering faculty: 97% male dominated; 2) *Nuclear engineering faculty*: 94.2% male dominated; 3) *Aerospace engineering faculty*: 92.1% male dominated; 4) *Petroleum engineering faculty*: 91.5% male dominated; 5) *Mechanical engineering faculty*: 91.5% male dominated.

Photos were culled from the *Google Image Search* index using the procedure outlined earlier. The search term used was '*engineering faculty*'. Thirty-two photographs were collected. From that number, sixteen were randomly selected and included in the study. *Firefighters*⁶⁰: 96.4 % male dominated (U.S. Census, 2000) The search term used was '*firefighter*'. Thirty-five photographs were collected. From that number, sixteen were randomly selected and included in the study

⁵⁸ Active duty or retired in any given year as long as the domination percentages were satisfied

⁵⁹ "Domination data" were obtained from *Engineering by the numbers* (American Society for Engineering Education, 2008)

⁶⁰ Both volunteer and professional firefighters were included.

2.1.1.4 *f*Dom collection

Sixty-four facial photographs of women working in female-dominated occupations⁴ were used. The *f*Dom collection drew from the following occupational orders, all of which are $\geq 90\%$ female dominated: 1) *Administrative assistants*: 96.60% female dominated; 2) *Preschool teachers*: 97.80% female dominated; 3) *Dental assistants*: 97.70% female dominated; 4) *Registered nurses*⁶¹: 92.40% female dominated. The search terms used were their occupational titles, i.e. ‘*Administrative Assistant*’, ‘*Preschool Teacher*’ etc. Respectively for each occupational order, twenty-two, twenty, nineteen, and twenty-two photographs were collected. From each occupational order, sixteen photos were randomly selected for inclusion in the study, except for the *Preschool Teacher* and *Administrative Assistant* orders (one photo was mistakenly added to the former and -given the fixed overall total- inadvertently dropped from the latter).

2.2 Phase II

In Phase II, facial masculinity was assessed subjectively.

2.2.1 *Participants*

Participants were recruited from UTA undergraduates enrolled in two upper division social science classes⁶². Sixty-six female and sixteen male volunteers participated. Of the sixty-six women volunteers, twenty were randomly selected as raters for the study. As the number of male volunteers was below the recruitment goal

⁶¹ The author did not restrict the sample to women who just had R.N. certifications. Women with advanced degrees and high status positions who also happened to have R.N. licensure and certification were also included.

⁶² One sociology and one psychology class

of 20, all male volunteers were selected as raters. Ultimately, thirty-six participants completed the study for extra credit (20 women and 16 men; $M = 24.56$ yrs; $SD. = 4.33$; range = 20 – 36 yrs).

2.2.2 Materials

2.2.2.1 Photo stimuli.

To focus attention away from extra-facial information, photo stimuli were rectangularly cropped so that the inner hairline and face outline remained visible⁶³. Further to control for facial (or image) size, interpupillary distance was standardized at 1.75 inches^{64,65} and, to achieve a more uniform look, all photos –if not already so- were converted into grayscale. Faces, lastly, were positioned and -if necessary- rotated so that the two pupils were on the same x -axis.

2.2.3 Procedure

After obtaining informed consent, participants were seated and oriented to the task. They were instructed that a facially masculine face has squarer jaws, broader cheekbones, more protrusive brow ridges, and a longer face.

2.2.3.1 Facial masculinity ratings⁶⁶

Participants independently rated the photo stimuli on a five-point Likert type scale of facial masculinity (1 = not masculine, 2=somewhat masculine, 3=moderately masculine, 4=masculine, 5=very masculine). Faces were presented using a *Microsoft*

⁶³ The ears, in other words, and most -if not all- of the hair was cropped out.

⁶⁴ Using the scale function of the *ImageJ 1.40g* 'Image' menu bar item

⁶⁵ See Boothroyd et al. (2005) or Penton-Voak et al. (2001)

⁶⁶ Facial dominance was not measured, as it's known to correlate very highly with facial masculinity (e.g. Fink et al., 2007; Neave et al., 2003), and as discussed before it's really the same "object".

PowerPoint[®] presentation in one of four random orders. Each photo remained on screen for 7 seconds. Each of the four consecutive rating segments consisted of 25-35 faces after which a short break of 1 minute was given. Multiple rating sessions took place and consisted of anywhere from 1 to 30 participants. The sessions were conducted in such a way to yield by random selection 10 participants per order (5 women and 5 men)⁶⁷.

Participants were instructed to place a checkmark next to any face they recognized. Recognized faces were to be eliminated from that data set. As none of the selected participants recognized any faces, no faces were eliminated. The mean score of each face was taken as the measure of facial masculinity. Interrater Reliability (Cronbach's Coefficient Alpha) for the sample was .96. (*Note: Facial masculinity ratings did not differ significantly across sex of rater* ($t^{34} = 1.262, p = .216$).

2.3 Phase III

In phase III, facial masculinity was assessed quantitatively. The measures selected were based in part on Penton-Voak et al. (2001) & Gangestad & Thornhill (2003).

2.3.1 Facial metrics

The study looked at four facial characteristics: eye area, face height, face width, and at eye-mouth-eye angle (*EmE*), a composite characteristic.

EmE was employed to check for its possible convergence with the facial masculinity ratings and the other quantitative measures employed (see below). As such,

⁶⁷ The exception being the fourth order where only 5 women and 1 man were run. This was due to the limited number of men in the volunteer pool.

the notion of whether *EmE* is an efficient index of facial masculinity was investigated. As noted earlier, the development of the brow ridge, face height, the jaw, and the chin is largely a function of the degree of one's exposure to sex hormones, particularly testosterone (Enlow & Hans, 1996; Thornhill & Gangestad, 1996), as is *EmE* which itself is a function of mid-face height^{68,69}.

Because of differences in image size⁷⁰, facial proportions were used in lieu of absolute measurement. Measurements are outlined and diagrammed below (see Figure 2.1). Unless otherwise stated, all measurements were to the nearest pixel or hundredths of an inch. Each dimension of each measure was measured twice yielding two measurements for each proportion⁷¹. The recorded value was simply the mean of the two. Repeatability correlations in addition were conducted to check for measurement reliability.

⁶⁸ Height from the upper mouth to the horizontal axis connecting the pupils

⁶⁹ Interpupillary distance, unlike facial height, does not differ significantly across sex (Danel & Pawlowski, 2007; Gangestad & Thornhill, 2003). The appearance of narrower set eyes in males may be related to the fact that men have lower eye height, shorter eye length, and larger faces generally than women (Gangestad & Thornhill, 2003; Koehler et al., 2004).

⁷⁰ Due to the mixed provenance of the photos

⁷¹ Once each using the applicable tool from the *ImageJ* and/or *Iconico* suites of graphic measuring tools (Rasband, 2007) (Iconico Inc., 2009a-b).

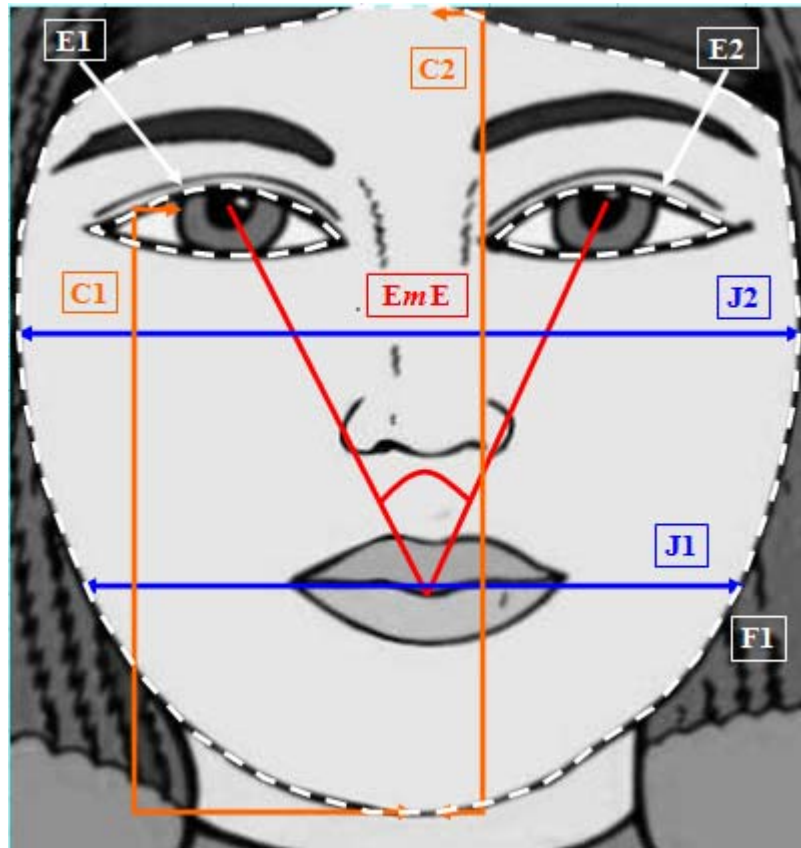


Figure 2.1 Facial proportion measures

2.3.1.1 Jaw breadth^{72,73}(J1/J2)

Jaw breadth was measured as a proportion of the longest *x*-axis of the cheekbones (*J2*). It is the breadth of the face perpendicular to the midpoint of *the y*-axis of *the upper lip crease and bottom lower lip margin (J1)*, see Fig. 2.1 -all things being equal, the greater the jaw breadth proportion the more masculine the face.

⁷² Remeasurement reliability was high ($r = 0.89, p = .000$)

⁷³ Using the *ImageJ 1.40g* 'Straight lines' tool (Rasband, 2007) and the 'Measure' option from the 'Analyze' drop down menu.

2.3.1.2 Lower face height⁷⁴ (C1/C2)

Lower face height was measured from the midpoint of the x -axis connecting and vertically bisecting the pupils down to the bottom of the chin ($C1$), see Fig. 2.1. Total face height was measured from the y -axis bisecting the face at the midpoint of the mouth (from the actual (or estimated) hairline to the bottom of the chin ($C2$))-the greater the lower face proportion the more masculine the face.

2.3.1.3 Total face height-to-width⁷⁵ (C2/J2)

Total face height was measured as specified in the previous measure ($C2$)-the greater the face height-to-width proportion the more masculine the face. Face width was measured as a proportion of the longest x -axis of the cheekbones ($J2$), see Fig. 2.1.

2.3.1.4 Eye area^{76,77,78}((E1+E2)/F1)⁷⁹

Eye area was measured as a proportion of total face area ($F1$). Eye area is defined as the total area produced by tracing around the inner eyelids of the eyes ($E1 + E2$ --see Fig. 2.1) - the more masculine the face the lower the eye area proportion⁸⁰.

⁷⁴ Remeasurement reliability was high ($r = 0.96, p = .000$).

⁷⁵ Remeasurement reliability was high ($r = 0.96, p = .000$).

⁷⁶ With the effect of smiling and ethnicity partialled out because of the tendency of the eyes to narrow during smiling, and the possible influence of ethnicity on the level of exposed eye area. Asians for example tend to have less exposed eye area.

⁷⁷ As an indirect measure of brow ridge development

⁷⁸ Remeasurement reliability was high ($r = 0.94, p = .000$).

⁷⁹ Using the *ImageJ 1.40g* Polygon 'Area selection' tool. The area was measured using the 'Measure' option from the 'Analyze' menu bar

⁸⁰ Eyes are smaller in masculinized faces because the eyes do not develop in proportion to the jaw, face, and chin; hence eyes in such faces occupy, relative to feminized faces, a lower proportion of the face (Gangestad & Thornhill, 2003).

2.3.1.5 Eye-mouth-eye angle (*EmE*)^{81,82}

Using straight lines, it is the vertex⁸³ created by connecting the center of each pupil with the center of the mouth⁸⁴ (Danel & Powlowski, 2007), see Figure 2.1. *EmE* is a function of interpupillary distance and mid-face height⁸⁵ (Danel & Powlowski, 2007)- the smaller the *EmE* angle the more masculine the face.

⁸¹ *EmE* angles were traced and measured using the *ImageJ 1.40g* 'Angle' tool

⁸² Remeasurement reliability for *EmE* was high ($r = 0.99, p = .000$).

⁸³ The point at which the sides of an angle intersect.

⁸⁴ The midpoint of the vertical axis created by the upper lip crease and bottom lower lip margin. The point was determined by the bisect function of the *ImageJ 1.40g* 'Straight Lines' tool

⁸⁵ Being an angle measure, it has the added advantage of being independent of face size.

CHAPTER 3

RESULTS^{86,87}

An occupational (*m/f dom*) group by ‘dependent variable’ correlation matrix⁸⁸ was generated to define relationships in the data. Results are shown in Tables 3.1 & 3.2. Descriptive statistics are also provided.

Table 3.1 Correlations

		Occupational Group ^{#,89}	Facial masculinity	Jaw breadth	Lower face height	Face height-to-width
Facial masculinity	Pearson Correlation	.314				
	Sig. (2-tailed)	.000				
Jaw breadth	Pearson Correlation	-.111 [@]	.285			
	Sig. (2-tailed)	.211	.001			
Lower face height	Pearson Correlation	.145	.179	-.057 [@]		
	Sig. (2-tailed)	.101	.043	.523		
Face height-to-width	Pearson Correlation	-.021 [@]	-.172 [@]	-.078 [@]	-.370 [@]	
	Sig. (2-tailed)	.818	.052	.382	.000	
Eye area	Pearson Correlation	.164 [@]	-.269	-.391	.169 [@]	.059 [@]
	Sig. (2-tailed)	.065	.002	.000	.056	.535
Eye-mouth-eye angle	Pearson Correlation	-.223	.104 [@]	.276 [@]	-.162	-.497
	Sig. (2-tailed)	.011	.245	.002	.068	.000
N=128	Mean	.50	2.489	.896	.610	1.399
	SD	.502	.714	.036	.025	.085

[#] Dummy coded [@] Relationship not in the expected direction

⁸⁶ Kolmogorov-Smirnov tests for all interval variables revealed no significant deviations from normality.

⁸⁷ Using the SPSS 16.0 statistical package

⁸⁸ Status variables were dummy coded: *fdom* = 0; *mdom* = 1.

⁸⁹ *mDom* or *fDom*

Table 3.2 Correlations II

		Eye area	Eye-mouth-eye angle
Eye area proportion	Pearson Correlation		
	Sig. (2-tailed)		
Eye-mouth-eye angle	Pearson Correlation	-.205	
	Sig. (2-tailed)	.021	
N=128	Mean	.012	49.173
	SD	.003	3.29

Dummy coded @ Relationship not in the expected direction

Occupational (*m/f dom*) group correlations were then defined through a series of general linear models (ANCOVA's), one for each dependent variable. For each model, *m/f dom* served as the fixed factor and *race*⁹⁰, *smiling*, *glasses*, *make-up*, *earrings*, and *age* as (three or more of) the covariates. If the model was significant, an additional iteration was generated using *occupational order* as the fixed factor.

In addition, a hierarchical (binary) logistic regression was performed to investigate the extent to which the dom-differentiating variables could predict occupational group.

3.1 Hypotheses

3.1.1 Hypothesis 1

Hypothesis 1 was supported. Women from male-dominated occupations ($M_{adj} = 2.678$ pts, $SE = .075$ pts) had a 16.4% higher facial masculinity rating⁹¹ than women from female-dominated occupations ($M_{adj} = 2.300$ pts, $SE = .075$ pts) [$F(1, 121) =$

⁹⁰ Race was collapsed into *white* versus *non-white* as there were too few cases in the latter's sub-categories. Race and the other status covariates were dummy coded: Race_{white} = 1- Race_{other} = 0.

⁹¹ Adjusted mean facial masculinity rating (mean adjusted for "nuisance variables").

12.046, $p = .001$]⁹². As a comparison in the author's previous study, high scoring males on a trait dominance measure⁹³ had a 12.5% higher facial dominance rating than low scorers⁹⁴. All the same, the magnitude of the mean difference (+.378 pts) was 'medium-large' to 'large' ($\eta = 0.30$) (Cohen, 1988).

The effect differentiated across occupational order as well $F(7, 114) = 3.880, p = .001$]. See Figure 3.1⁹⁵ for the means distribution (*Note: Bars sharing the same color-patterned line were significantly different from each other*^{96,97}).

⁹² Controlling for *race, smiling, glasses, make-up, earrings, and age*.

⁹³ Ray's Dominance Questionnaire (RDQ) was the trait dominance measure used. It is a self-report measure (Ray, 1981). High and low scorers were defined along a median split

⁹⁴ The parallel being findings discussed earlier of women from male-dominated occupations scoring higher on such measures than women from female-dominated occupations.

⁹⁵ CEO: Chief executive officer; M.O: Military officer; ENG: Engineering professor; F.F.: Firefighter; A.A: Administrative Assistant; Pre-K: Preschool teacher; D.A: Dental assistant; R.N.: Registered nurse

⁹⁶ At least at $p \leq .05$

⁹⁷ Pairwise comparisons were performed using a simple effects contrast analysis.

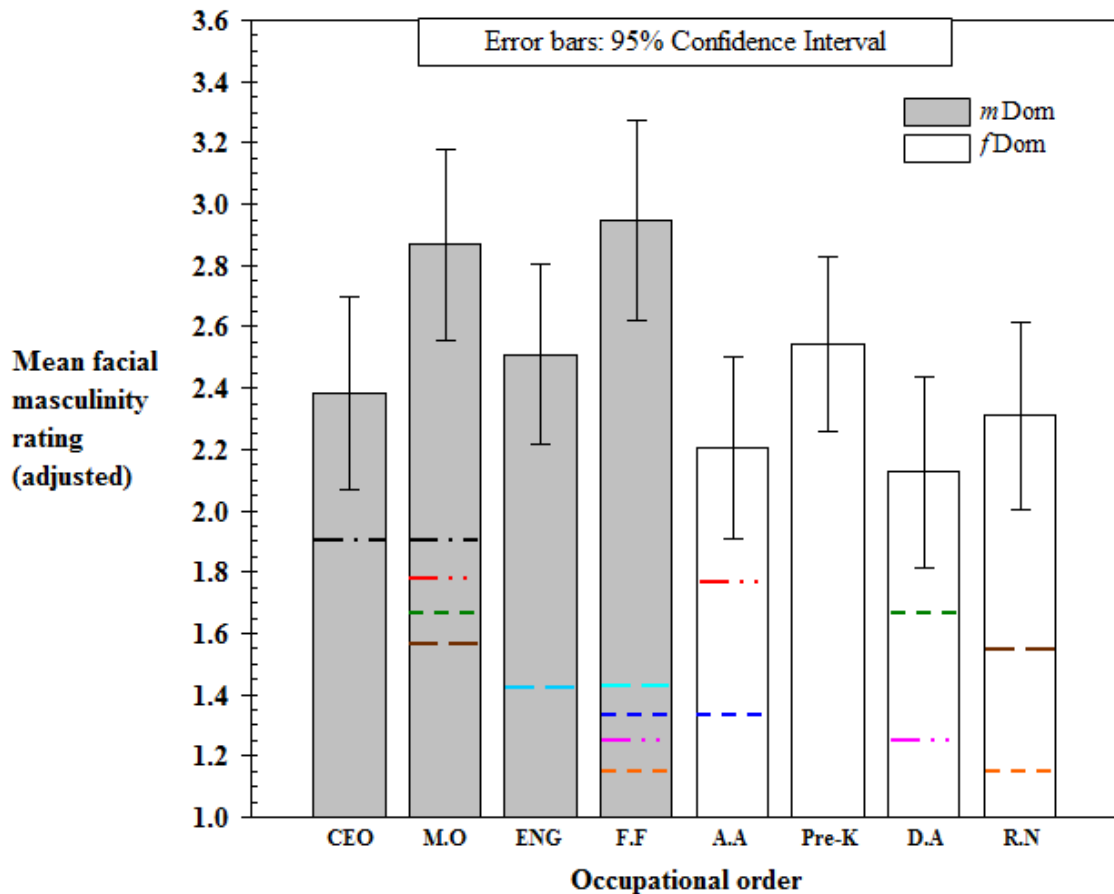


Figure 3.1 Occupational order on mean facial masculinity rating (adjusted)

Conspicuous in Figure 6 is the *Pre-K* order ($M_{adj} = 2.542$ pts, $SE = .143$ pts). Its adjusted mean is higher than that of two *mDom* orders (*CEO*: $M_{adj} = 2.382$ pts, $SE = .157$ pts and *ENG*: $M_{adj} = 2.510$ pts, $SE = .148$ pts) and higher than any other *fDom* order, i.e. > 2.300 pts, and in addition over 3 S.E's above the *fDom* group mean.

In addition to having a lower adjusted mean than the *Pre-K* order, *CEO* and *ENG* lie below the adjusted mean of their occupational group: *CEO*-over four S.E's below the mean, and *ENG* over two S.E's below.

3.1.2 Hypothesis 2

Hypothesis 2 was not supported. Women from male-dominated occupations ($M_{adj} = .893$, $SE = .005$) did not have greater jaw breadths than women from female-dominated occupations ($M_{adj} = .900$, $SE = .005$) [$F(1, 122) = 1.165$, $p = .283$]^{98,99}.

3.1.3 Hypothesis 3

Women from male-dominated occupations ($M_{adj} = .615$, $SE = .003$) did have greater lower face height proportions than women from female-dominated occupations ($M_{adj} = .606$, $SE = .003$). The difference was only mildly significant however [$F(1, 123) = 3.340$, $p = .070$] and thus did not confirm the hypothesis. For comparison, men have an average lower face height proportion of .62, and women an average of .60 (Penton-Voak et al., 2001).

3.1.4 Hypothesis 4

The face height-to-widths of women from male-dominated occupation ($M_{adj} = 1.400$, $SE = .011$) was no greater than that of women from female-dominated occupations ($M_{adj} = 1.398$, $SE = .011$) [$F(1, 122) = 0.140$, $p = .907$]. Hypothesis 4 thus was not supported.

3.1.5 Hypothesis 5

The analysis revealed a significant effect. It was however in the wrong direction. Against the prediction, women from *female-* not *male-*dominated occupations had *smaller* eye areas ($M_{adj} = .012$, $SE = .000$ vs $M_{adj} = .013$, $SE = .000$, *respectively*) [$F(1,$

⁹⁸ Controlling for *race*, *smiling*, *glasses*, and *age*.

121) = 4.414, $p = .038$] (*Note: the result is not tantamount to concluding that facial masculinity and eye area bear no relation, see Table 3.1*).

3.1.6 Hypothesis 6

Hypothesis 6 was confirmed. Women from male-dominated occupations ($M_{adj} = 48.323^\circ$, $SE = .405^\circ$) had smaller EmE angles than women from female-dominated occupations ($M_{adj} = 50.023^\circ$, $SE = .405^\circ$) [$F(1, 122) = 8.283$, $p = .004$]. At an *eta* of 0.26, the effect was of a medium magnitude.

For some context, men have an average EmE angle of 47.68° ($SD = 2.42^\circ$), and women an average EmE angle of 50.16° ($SD = 2.71^\circ$) (Danel & Powlowski, 2007), a mean difference of -2.48° (versus the -1.7° obtained here). The observed intra-sexual by inter-occupational difference in other words was not larger than the intersexual difference.

The “effect” also distributed across occupational order [$F(7, 116) = 2.386$, $p = .026$]. As before, simple effects contrasts were performed. Several significant pair differences manifested. See Figure 3.2 (*Note: Again, bars sharing the same color-patterned line were significantly different from each other*¹⁰⁰).

⁹⁹ Men according to (Koehler et al., 2004)’s sample have jaws that are 6.4% wider than women (see Appendix A of Koehler et al (2004), table 2; available on The Royal Society’s Publications Web site).

¹⁰⁰ At least at $p \leq .05$

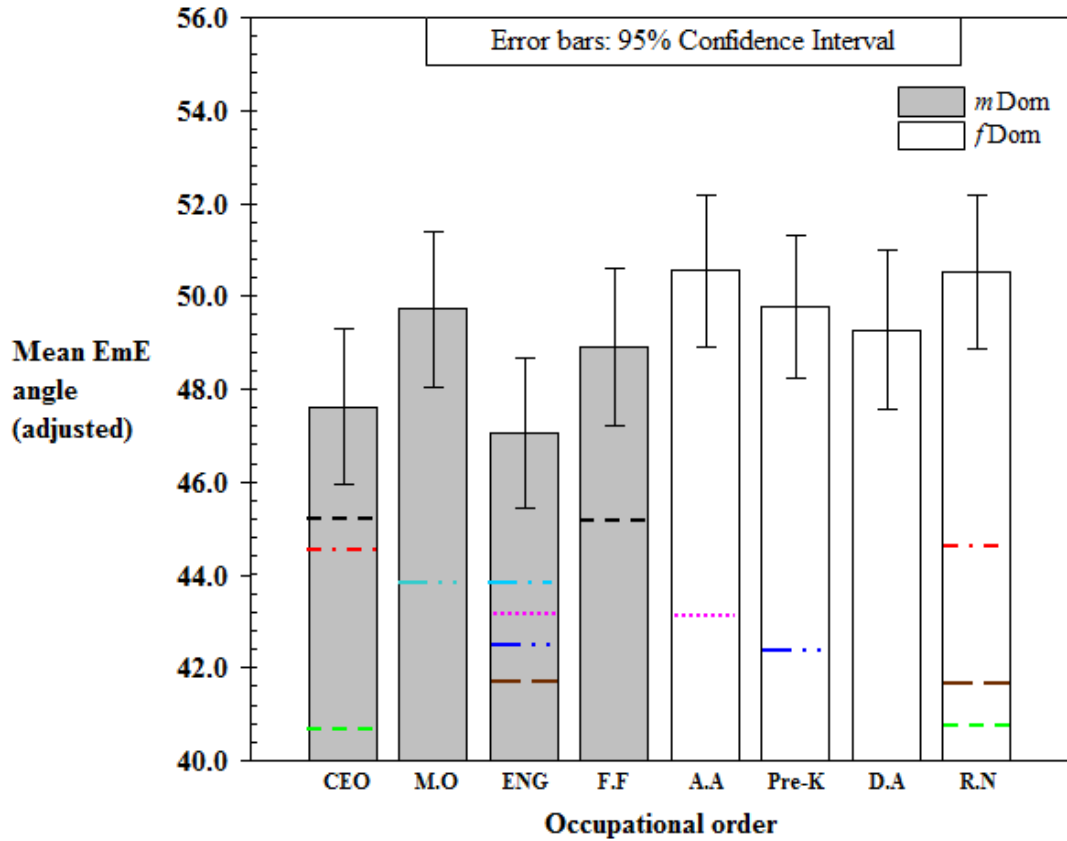


Figure 3.2 Occupational order on mean *EmE* angle (adjusted)

Organizing the *EmE*'s in ascending order yielded one anomaly. The *D.A* order had smaller *EmE*'s than the *M.O* *mDom* order, ($M_{adj} = 49.274^\circ$, $SE = .867^\circ$) vs. ($M_{adj} = 49.727^\circ$, $SE = .848^\circ$). Every other *mDom* *EmE* however is smaller than every other *fDom* *EmE*. Additionally, the two *mDom* orders with the highest facial masculinity ratings are the orders with the highest *EmE*'s, the opposite of what would be predicted.

3.2 Secondary analysis

3.2.1 *EmE as a convergent measure*

Conspicuous was the fact that *EmE* did not converge with rated facial masculinity at all ($r = .104, p = .245$), nor did it converge much -if at all- with the other quantitative measures, see Table 3.3.

Table 3.3 Correlations III

N=128		Eye-mouth-eye angle
Jaw breadth	Pearson Correlation	.276@
	Sig. (2-tailed)	.002
Eye area	Pearson Correlation	-.205@
	Sig. (2-tailed)	.021
Lower face height	Pearson Correlation	-.162
	Sig. (2-tailed)	.068
Total face height-to-width	Pearson Correlation	-.497
	Sig. (2-tailed)	.000

@ Relationship not in the expected direction

3.2.2 *Hierarchical logistic regression*

Controlling for three *m/f* dom covariates, smiling, race, and lower-face proportion¹⁰¹, a hierarchical (binary) logistical regression was conducted to assess whether the two *m/f* dom-differentiating variables, rated facial masculinity and *EmE*, were predictive of occupational group.

¹⁰¹ The model could not sustain any other combination of *m/f* dom covariates without undue levels of multicollinearity. Other covariates just correlated too much with the variables in the model. Mean centering had no appreciable effect on the collinearity

Predict occupational group membership they did (*Wald Statistic* - $\chi^2 = 23.437$, $df = 2$, $N = 128$, $p = .000$)¹⁰². Each rating point increase in rated facial masculinity increased the odds of picking the correct occupational group by 332% (*Wald Statistic* - $\chi^2 = 13.988$, $df = 1$, $p = .000$), and each EmE degree increase increased the odds of picking the correct occupational group by 82% (*Wald Statistic* - $\chi^2 = 9.251$, $df = 1$, $p = .002$). Rated facial masculinity and EmE increased the correct classification of cases from 60.2% to 70.3% relative to the covariates alone (68.8% of the cases of women in female dominated occupations and 71.9% of the cases of women in male-dominated occupations), see Table 3.4 for the regression coefficients, Wald test, and odds ratio for each of the predictors and covariates.

Table 3.4 Logistic regression

	<i>B</i>	Wald χ^2	<i>p</i>	Odds Ratio
Smiling	1.488	5.746	.017	4.429
Lower face proportion	7.142	.724	.395	1263.468
Race	.613	1.086	.297	1.846
Facial masculinity	1.201	13.988	.000	3.323
EmE	-.203	9.251	.002	.817

¹⁰² Overall model stats: (*Wald Statistic* - $\chi^2 = 30.673$, $df = 5$, $p = .000$) and accounted for 21.3% of the variance in the occupational group variable (Cox & Snell R^2)

CHAPTER 4

DISCUSSION

The study investigated whether women from male-dominated occupations are more facially masculine than women from female-dominated occupations. The proposition is an inferential question, one born of a transitive association between two evidentiary lines: 1) evidence linking facial masculinity (A) with dominance (B), and evidence linking dominance (B) with women in male-dominated occupations (C), ($A \rightarrow B$ and $B \rightarrow C$, $A \rightarrow C$).

The study sought not only to test the proposition but to bring more definition to the “problem” of occupational sex segregation, i.e. why certain male-dominated occupations, e.g. engineering, firefighting, and the military, still remain sex segregated (National Science Foundation, 2007; U.S. Census, 2000; U.S. Department of Defense, 2007). The study subscribed to an evolutionary view, one largely advanced by Browne (1998, 2002), and rather than staying within the confines of the existing work, the study expanded it by invoking another theory, one never before applied in the context of occupational sex segregation: the handicap principle qua costly or honest signaling theory (HST)

4.1 Rationale

If the evolutionary and biological evidence to date explaining occupational sex segregation is valid (see the ‘Introduction’ and/or Browne (1998, 2002)) then it should

follow that the women populating male- and female-dominated occupations should also differ in ways that extend from the current evidence.

In other words, if occupational sex segregation is largely if not wholly a function of sex differences in temperament, behavior, and cognitive abilities, women who are more male-like along these dimensions should preferentially populate occupations that leverage these attributes and largely depend on them for success, i.e. male-dominated occupations

Given the attributes themselves (and sex differences for that matter) are all undergirded by hormonal and evolutionary processes, it would be reasonable to hypothesize that other manifestations of these processes should be evident, whether one compares men & women or women from male-dominated occupations & women from female dominated occupations. Facial masculinity is one such manifestation. It extends from the finding that women in male-dominated occupations are more dominant than women in female dominated occupations as dominance is statistically dependent with facial masculinity.

Inasmuch then as men are more facially and behaviorally masculine than women then it should follow that women from male-dominated jobs, because they are more behaviorally masculine and dominant, should be physiognomically more male-like (or more facially masculine) than women from female-dominated occupations.

Given that the handicap principle (qua costly or honest signaling theory --HST) is itself an extension of evolutionary theory and also implicates hormonal and

evolutionary processes, it is an appropriate platform by which to predict the differences articulated in the hypotheses, as facial masculinity is in effect a “handicap”.

4.2 Hypotheses

4.2.1 Hypothesis 1

Hypothesis 1 was supported. Women from male-dominated occupations had a higher facial masculinity rating than women from female dominated jobs. Agreement on that front further was high (Cronbach’s $\alpha = .96$), much like studies before it (e.g., Koehler et al., 2004; Boothroyd et al., 2005; Fink et al., 2007).

This finding however does not falsify the evolutionary account subscribed to here *or* the non-evolutionary account behind occupational sex segregation. It supports *both* actually and falsifies *neither*. Simply stated, the study could not and did not -as designed- adjudicate between the two.

One could interpret the finding to mean that facial masculinity and dominance only come to be associated (SET) and then proceed to explain occupational sex segregation through a transitive association with the finding that women in male-dominated occupations are more dominant than women in female dominated occupations or one could interpret the finding as supporting the idea that facial masculinity and dominance are fundamentally and biologically linked and explain occupational segregation anew through –again- a transitive association with *the finding that women in male-dominated occupations are more dominant than women in female dominated occupations.*

Whether one proceeds via the former or the latter, the finding itself remains preliminary. It still needs to be replicated under more controlled conditions as the controls employed could not – in every circumstance- filter out *every* non-facial clue short –that is- of cutting into the “facial frame”^{103,104}.

4.2.2 Hypothesis 2

The hypothesis was not confirmed. Women from male-dominated occupations did not have greater jaw breadths than women from female-dominated occupations. Comparing the facial qualities of women in this way however has never been attempted so norms as to what one might obtain do not exist. It might be that facial differences between women by occupational category do not encompass the jaw. Until more study is completed, it is difficult to tell.

One can certainly state however that the result is inconsistent with what one would expect given the rationale as to how these women should differ. The fact that the measure did not correlate significantly, or in the right direction, with lower face height, face height-to-width, or *EmE* only underscores that.

4.2.3 Hypothesis 3

Women from male-dominated occupations *did* have greater lower face heights than women from female-dominated occupations. The hypothesis however was not

¹⁰³ One could make the case however that extra-facial information, if visible, is not likely to stand independent of the disposition and physiognomy of the pictured. Given the statistically dependent link in women between facial masculinity and dominance (e.g., Berry & Brownlow, 1989; Berry, 1990; Berry, 1991; Cherulnik et al., 1990; Mazur & Booth, 1998), a more behaviorally dominant and hence more facially masculine woman would probably not style or cut her hair in a more overtly feminine way than a more behaviorally submissive and facially feminine woman.

¹⁰⁴ All the same, it is questionable whether those clues could have biased the sample, especially in light of the number of controls instituted. That possibility however was *not* investigated.

confirmed as the result fell just short of statistical significance¹⁰⁵. The heights themselves, respectively .615 and .606, however were not that far off the values observed for men and women, .62 and .60 respectively (Penton-Voak et al., 2001), suggesting that the values observed and the intersexual values may run somewhat “parallel” to each other but given the sample size were just not statistically evident.

One other thing worth mentioning is the fact that face height unlike jaw breadth correlates with both occupational category *and* facial masculinity, the former at a mildly significant level ($r = -.346$, $p < .001$) the latter at a significant one ($r = -.346$, $p < .001$). The fact that there is a relationship at all with both variables may suggest that facial height –as distinct from facial width- may lie more at the core of what may –in terms of objective characteristic—facially differentiate women by occupational category. This perhaps becomes clearer when we consider the result of Hypothesis 6.

4.2.4 Hypothesis 4

Like Hypothesis 3, Hypothesis 4 was not supported. The face height-to-widths of women from male-dominated occupation were no greater than that of women from female-dominated occupations¹⁰⁶.

¹⁰⁵ Supplemental analysis: As noted by Koehler et al. (2004), total face height unlike the other facial height measures incorporates a soft anatomical feature, i.e. the hairline. Lower face and mid-face height by contrast do not. They incorporate, or at least are encased or overlaid by, hard anatomical features, i.e. the chin, the eye socket, and the margin between the upper and lower anterior teeth. Along with the result of Hypothesis 6 this fact led the author to revisit the measures incorporating total face height. Initially nothing happened. That is, when mid-face height was substituted for lower face height and lower face height substituted for (total) face height, no significant effect resulted. Only when mid-face height was the only face height dimension indexed—whether as part of a proportion or under a facial size control- did results consistently become significant, e.g. mid-face height/face width in lieu of total face height/face width, and mid-face height proper in lieu of lower face height.

¹⁰⁶ Supplemental analysis: As discussed in the previous footnote, this seems to come down to which facial height dimension is measured. When lower face height is used in lieu of total face height, the result becomes “more significant” but not “significant enough.” Only again, when mid-face height becomes the facial height dimension measured do results become significant. As in Hypothesis 3, mid-face height seems to be the key. In any case, mid-face height seems to be the key determinant, whether as part of a proportion, e.g. mid-face height by face width and

4.2.5 Hypothesis 5

Women from *female*- not *male*-dominated occupations had *smaller* eye areas. This result runs against the notion that more dominant women should -by virtue of a more pronounced “testosterone signature”- have more masculinized faces and hence smaller eyes in relation to total face area. The eyes -as discussed earlier- do not develop in proportion to the jaw, face, and chin and hence eyes in masculinized faces should occupy, relative to feminized faces, a lower proportion of the face (Gangestad & Thornhill, 2003). Sex differences however may shed some light as to why the predicted pattern was not exhibited.

Assuming differences across sex are but an amplified pattern of what one would expect to find across women by occupational category, then there really no real sex differences to begin with. Studies to date simply do not evidence any consistent sex difference pattern, i.e. whether across eye area or otherwise, e.g. eye height or eye length.

One study for example showed no sex difference in eye area (Koehler et al., 2004), while another study exhibited a difference but only in eye height (Gangestad & Thornhill, 2003), and still another showed a differences but on a different dimension, eye length (Penton-Voak et al., 2001). This is made all the murkier by the fact that eye

EmE or when controlled under a linear measure, e.g. mid-face height (jaw width control). *Note: IPD does not differ by occupational category, IPD (jaw control): [F(1, 122) = 1.493, p = .224]; IPD/x-axis: [F(1, 122) = 0.258, p = .612]; nor does it differ by sex (Gangestad & Thornhill (2003), making mid-face height again all the more significant as a differentiator*

area correlates significantly and in the predicted direction with rated facial masculinity, i.e. ($r = -.269, p = .002$).

Similar to what could be said of Hypothesis 2, eye area may just not be relevant when it comes to facially differentiating women by occupational category.

4.2.6 Hypothesis 6

Except for the significant result, the result of Hypothesis 6 is analogous to Hypothesis 3. The inter-occupational group difference seems to parallel the intersexual difference, 69% of the difference in fact. *M*Dom women and men (as a whole) are just a little more than half degree apart in terms of *EmE* angle, 48.32° vs. 47.68° and *f*Dom women and women (as a whole) less than .15 degrees apart, 50.023° vs. 50.16° . The intersexual difference –in other words- may be but an amplified pattern of the inter-occupational group difference but much again as before, further study and replication is needed to fully define the result.

4.3 Limitations

Given some null results, the study could not -as designed- fully and unambiguously support the contention that *m*Dom women are more facially masculine than *f*Dom women, nor could it in the process stand fully consistent with the evolutionary based argument behind occupational sex segregation-the one proffered here (Browne, 2006).

For instance, women from male-dominated occupations were not found to have larger jaw breadths, lower face-heights, face height-to-widths, and eye areas than

women from female-dominated occupations¹⁰⁷. Given the exploratory nature of the research, it may be that these measures do not encompass how these women differ especially in light of the fact that they did differ along their *EmE* angles and along their facial masculinity ratings. The measures to date have only been employed and only been successful in differentiating men from women not women from women, and as such they may have been contraindicated here. Nonetheless, the fact remains. The measures did not evidence any differences across occupational category.

Further in light of the qualifier attached to Hypothesis 1, a questionable result may not be out of the question. This is especially possible given some uncertainty behind the effectiveness of the controls instituted. If that is the case then that would put either or both *the evolutionary based explanation behind the facial masculinity-dominance connection* and *the testosterone based explanation behind why women in male-dominated occupations are more dominant* into question, an unlikely state of affairs given a significant body of study stands behind both findings. Strictly speaking however, either possibility cannot be ruled out.

In that instance, either or both *the Socialization/Social Expectancy Theory explanation behind the facial masculinity dominance link* and *the socialization based argument behind the why women in male-dominated occupations are more dominant* become questionable¹⁰⁸ as well. In effect, both explanatory approaches behind

¹⁰⁷ It should be noted that a parallel pattern of differentiation did manifest with the lower face height measure, one that along with *EmE* seemed to parallel the intersexual difference.

¹⁰⁸ The latter mechanism would be a form of Socialization/Social Expectancy Theory where women in male-dominated occupations are expected to- and reinforced for- behaving dominantly. Dominance in that instance would express inasmuch as it's socially demanded in male-dominated occupations which is what's implied by the finding in the first place -if looked at from a social conditioning point of view.

occupational sex segregation become questionable as neither is supported and both are falsified.

If we consider the non-biological theories of occupational sex segregation in this context then it would seem that explanations that do not incorporate socialization or at least the ones that do not incorporate it directly would have the advantage, i.e. more market based theories, e.g. neoclassical/human capital theory and statistical discrimination theory. These explanations deemphasize socialization as a factor.

In the other instance, i.e., if we err more on the side of Hypothesis 1 being a positive result, we are still in the same boat. We can just as easily invoke socialization-based explanations as we can evolutionary ones. We can account for how facial masculinity and dominance come to be related through Socialization/Social Expectancy Theory¹⁰⁹ or HST qua the handicap principle. We can also account for the finding that women in male-dominated occupations are more dominant, by again explaining it via Socialization/Social Expectancy Theory or HST qua the handicap principle. In this instance, both explanatory approaches behind occupational sex segregation are supported and neither is falsified.

If we consider the non-biological theories of occupational sex segregation in this context, then perhaps the explanations that emphasize non-market forces would be more favored, e.g. institutional inertia, patriarchy, gender-role socialization, status attainment theory. Consistent with England et al.'s (1988) sociological characterization, perhaps

¹⁰⁹ See the '*Facial masculinity and dominance under an alternative view*' section

one could view each theory as part of the overall phenomenon in the sense that they all may be interacting within a complex reciprocal feedback system.

The finding from Hypothesis 6 is perhaps more straightforward in that it does not lend itself to explanations other than a testosterone-based one. One would be hard-pressed to claim that people are aware of anybody's or everybody's *EmE* measurement. That probability of it somehow being accounted for by non-physiological theories is remoter still. The only explanation for the finding -if we afford it some validity- is the testosterone-based explanation advanced earlier in the introduction, i.e. the fact that testosterone –among its facial masculinizing effects- causes the lengthening of the lower face¹¹⁰. To the extent that a marginally significant finding qualifies, this dovetails with the finding from Hypothesis 3 that *mDom* women have marginally longer lower faces than *fDom* women. To be fair however the *EmE* finding does not correlate at all in the predicted direction with rated facial masculinity. Where that leaves the finding at least for now is uncertain. The finding like the one from Hypothesis 1 simply needs more study.

4.4 Other testosterone markers

If we conceptualize for the sake of discussion that facial masculinity¹¹¹ is a physical marker not only of dominance potential but of the likelihood of making more male-like occupational choices then the possibility exists that other testosterone-based

¹¹⁰ *EmE* is basically a triangular or trigonometric proportion of mid-face height and IPD. Supplemental analysis:

¹¹¹ Inasmuch as facial masculinity is a valid correlate of occupational choice in women

markers may also indicate the probability of choosing more male-dominated occupations¹¹²

4.4.1 2D:4D

2D:4D is the ratio of the lengths of the second and fourth manual digits. It -like facial masculinity- is a sexually dimorphic trait as women have higher 2D:4D ratios than men (Manning et al. 1998). The index and ring fingers of women unlike men tend to be of equal in length ($2D:4D \geq 1$). Men instead have longer ring than index fingers ($2D:4D \leq 1$).

Much like facial masculinity, 2D:4D is determined by one's level of prenatal androgen exposure. More androgen exposure induces greater growth of the ring finger relative to the index finger (Manning et al., 1998). As such, 2D:4D is conceptualized as an index prenatal androgen exposure (Manning et al., 1998).

Like all sexually dimorphic traits, sex differences are but statistical relationships. That is, there are women who have more male-like ratios ($2D:4D \leq 1$) and men who have more female-like ratios ($2D:4D \geq 1$).

Confining our discussion to the former, we find that women with more male typical 2D:4D's, i.e. $2D:4D \leq 1$, self-report as more assertive and competitive than women with more female typical 2D:4D's ($2D:4D \geq 1$) (Wilson, 1983), and as more masculine in identity (Csatho et al. 2003). They also tend to be more athletic and fit (Weisfeld et al. 1984; Pokrywka et al. 2005; Honnekopp et al. 2006), more dominant and aggressive (Manning & Fink, 2008; (Benderlioglu & Nelson, 2004), and perform

¹¹² Testosterone markers other than the ones identified here, i.e. facial masculinity in general or *EmE* in the specific

better on cognitive tests that measure spatial and numerical ability (Kempel et al., 2005)¹¹³.

This “masculinizing” effect is perhaps more directly evident in females with congenital adrenal hyperplasia (CAH), a recessive disorder that causes elevated levels of prenatal androgens during fetal development (Hines, 2006). Females with this condition tend to exhibit lower 2D:4D ratios than matched controls (Brown, Hines, Fane, & Breedlove, 2002; Okten, Kalyoncu, & Yaris, 2002). They also show an increased preference for male-typical behavior throughout the life course than controls, and a decreased interest for female typical behavior (Berenbaum & Snyder, 1995).

CAH females also outperform matched controls on tests of spatial orientation and visualization (Hampson, Rovet, & Altmann, 1998) [spatial relations test], (Resnick, Berenbaum, Gottesman, & Bouchard, 1986) [mental rotation test].

The inference from these data is that women with more masculinized 2D:4D’s may make -consistent with their disposition- more male-typical occupational choices. 2D:4D could thus be studied in that context.

4.4.2 Height

Height also being a sexual dimorphic trait also has a relationship with androgens. Circulating levels of androgens play a role in regulating the rate and growth in height from mid-childhood to later adolescence, when human beings usually reach

¹¹³ Spatial and mathematical ability as discussed earlier are at a premium in occupations like engineering and physics, occupations that are primarily male-dominated.

their permanent height (Zemel & Katz, 1986). As such, height can also be conceptualized an index of masculinization

Consistent with the characterization, height is known to correlate with social dominance (Eisenberg, 1937), and seems to bear some positive relationship with career advancement (Melamed & Bozionelos, 1992), and increased (within-occupation) status (e.g., Egolf & Corder, 1991; Hensley, 1993; Weisfeld & Beresford, 1982). Taller women further are rated as more assertive, more ambitious, and more intelligent than shorter women (Chu & Geary, 2005)

Deady & Smith (2006) also investigated height in women. They found that height in pre-reproductive women (aged 20–29) was negatively correlated with reproductive ambition, e.g. a lower value attached to having and taking care of children, and positively correlated with career ambition and career competitiveness. In women over the age of 45, height positively correlated with decreased reproductive events, i.e. a higher age before the first child, and fewer children overall, and an increased career orientation as well.

Whether height could predict the propensity of women to choose more male-dominated occupations is not known but the fact that it correlates with factors like social dominance and status suggests the possibility.

4.4.3 *WHR*

WHR, or the waist to hips girth ratio, like all the characteristics cited is also sexually dimorphic. Women tend to have lower WHR due to their gynoid (hourglass) pattern of fat distribution. The WHR of men hovers around $\geq .9$ as they preferentially

store body fat around the truncal area rather than the hips. The inference therefore is that the higher the WHR the more male-typical the value. As such, WHR like the other characteristics is also an index of masculinization.

Given the positive relationship, we can envision that the higher the WHR the higher the testosterone levels. Quite correctly, higher WHR's, i.e. 0.7-1.0, correlate with higher levels of testosterone (DeRidder et al., 1990; Evans, Hoffman, Kalkhoff, & Kissebah, 1983). Lower WHR's, i.e. ≤ 0.7 , thus correlate with lower testosterone levels.

Behaviorally there are also distinctions along that gradient, higher WHR's in women are associated with greater assertiveness, more competitive feelings, and increased displays of aggression (Cashdan, 2003), and an increased likelihood of overstating social rank (Cashdan, 1995). Women with high WHR's further, if they bear kids, have their first borns at later ages (Kaye et al., 1990), and tend on the whole to be less fertile as higher testosterone levels can handicap fertility (Jasienska et al., 2004), and increase the risk of polycystic ovary syndrome and other morbidities like cardiovascular disease (Zhang et al., 2004) and diabetes (Hartz et al., 1984). The latter two on average are more prevalent in men. WHR additionally is known to negatively correlate with 2D:4D, i.e. the more masculine the 2D:4D ratio the more masculine the WHR (Manning et al., 2000).

In any case, Cashdan (2008) theorizes that the evolution of high WHR's in women relate to trade-offs present in the ancestral environment, i.e. Dominance/Competitiveness versus Fertility. Essentially, the fitness benefits associated

with being more dominant can offset any fertility costs if the environmental conditions are such that there is more to gain from being more competitive versus more fertile.

That positive trade-off is often the case when resources become scarce as the ability to effectively compete is more at a premium then versus when resources are more abundant. In order to maintain such a disposition however, a woman has to have threshold levels of testosterone which happen to conflict in terms of optimality with maintaining better fertility. But as discussed, when resources are more rather than less scarce it actually pays in terms of fitness to be more dominant and competitive rather than less dominant but more fertile. A mother and her children end up doing better in those circumstances than a more fertile but less competitive woman and therefore she and her offspring gain a reproductive advantage over her “less endowed” but more fertile counterparts.

The logic thus extends to the occupational sex segregation problem in the sense that the behavioral benefits associated with higher WHR's have fundamental utility as it regards more male-dominated occupations as competitiveness and dominance are more at a premium there than they are on average in more female dominated occupations where by and large there is less status and less pay up for competition.

In that sense then, WHR may along with the other “markers” described bear a relationship with the probability that a women may choose a more rather than a less male-dominated occupation.

4.5 Future research

The logic articulated in the WHR section applies globally to all the markers described as they are all -like WHR- underpinned in one way or another by testosterone levels, as they all in some measure manifest its behavioral effects. To the extent that these markers are mediated by the action of testosterone, both pre- and postnatally, we can reasonably expect that the markers should correlate in ways consistent with the way they distribute across testosterone levels.

We should also in turn expect that the concentration of these markers will differ across occupational category consistent with the way they distribute across testosterone levels. That is, women from male-dominated occupations should possess marker values that are individually and/or collectively consistent with higher rather than lower levels of testosterone. The converse alternately should hold with women from female-dominated occupations.

Further, the consideration of these markers should make the exercise of predicting occupational group membership a more exact exercise than otherwise would be the case if only individual markers were considered. This along with a more streamlined and controlled methodology should be the object of further study.

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BIOGRAPHICAL INFORMATION

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