Sexual Selection and Human Breast Morphology

By

Melanie Duncan

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Abstract

Human females, uniquely among primates, develop prominent breasts during puberty, well before reproduction occurs. Adipose tissue in breasts forms part of the “gynoid” fat distribution, involving the hips, thighs, buttocks and breasts of women. Breasts are thus characterised as secondary sexual characteristics, and their evolution may be due, at least in part, to the effects of sexual selection. This partial reversal of the usual pattern of male adornment may be related to high paternal care in humans. Breast morphology is complex, so that women vary not only in the size and shape of their breasts, but also in the size, shape and pigmentation of their areolae and nipples. These traits change with reproductive status and age. Breasts are more prone to fluctuating asymmetry than many other features of human anatomy and such asymmetry may be closely related to some measures of reproductive success.

This thesis used digitally altered images to investigate the impact of morphological changes on perceptions of attractiveness and other qualities. Study 1 investigated the impact of four breast sizes and three areola colours on the perceptions of two hundred participants. Breast size significantly impacted all ratings. Attractiveness and health ratings were maximised at the intermediate breast size for the lightest and original coloured areola, and at the largest breast size for the darkest areola. Ratings of nurturance, sexual maturity and estimates of age increased stepwise from the images with undeveloped breasts to the images with the largest breasts. Areola colour interacted with breast size. Darker areola were judged less attractive, less healthy and less nurturing when paired with small or intermediate breasts, but increased these ratings when paired with large breasts. There was no strong effect of areola colour on ratings of images with undeveloped breasts or on ratings of sexual maturity and age. Study 2 investigated the effect of breast asymmetry on attractiveness and health

ratings using data provided by two hundred participants. Increasing levels of asymmetry, created by modifying one breast to increase the apparent volume (four levels from 102.5% to 110% of the original) or position (four levels from 1%-4% of the length of the image) resulted in progressively lower ratings. The differences in ratings between the images with extreme levels in asymmetry (107.5% vs 110% and 3% vs 4%) were smaller. Images that had been modified in the models left (and so seen on viewer's right side) were given higher ratings than those modified identically but on the other side. This may be an expression of a phenomena known as pseudoneglect, where people appear to attend more to the left. In Study 3, a diverse selection of images, taken from previously published reports on human breast morphology and attractiveness, were compiled as a single questionnaire and shown to 37 participants. The purpose of this pilot study was to assess the impact of different image types on ratings of attractiveness and health. Photographic images were rated higher than line drawings or silhouettes. Photographs may be more ecologically valid, as they are more realistic and can be tailored to match the study population. The results presented in this thesis indicate that variations in human breast size, areola colour and breast asymmetry have measurable effects on the perceptions (of both sexes) of attractiveness and health. Breast size also has significant impacts on perceptions of nurturance, reproductive status and age, whereas areola colour has less effect on these ratings. Questionnaire studies employing photographs are likely to be more effective than more stylised images. Morphological changes in the human breast may signal mate value and fertility and therefore may have been subject to sexual selection, as well as natural selection, during human evolution.

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Chapter 1 Introduction

Breast morphology and physiology

Human breasts are unusual in two features. The first is their extremely early development, in comparison to other mammals (Howard and Gusterson 2000); the other is that they are permanently enlarged with adipose tissue (Arieli 2004). These two features develop at puberty, in a process stimulated by oestrogen and progesterone (Lamote et al. 2004; Levin 2006).

The human breast

Adult structure

The adipose tissue of the breast is interspersed with the glandular tissue, (despite several major texts showing them to be cleanly separated) (Nickell and Skelton 2005). The glandular and adipose tissue are held together by connective tissue (Howard and Gusterson 2000), including ligaments holding the structure up and away from the chest wall (Gefen and Dilmoney 2007). Over time these ligaments stretch, causing ptosis, often causing the breast to lie against the lower ribs or stomach (Levin 2006). Absolute breast sizes of different populations have sporadically been reported in the published literature. These have reported volumes of single breasts ranging from 232 mL (US women, average age 24: Katch et al. 1980) 312 cubic centimetres (Swedish women, average age 21: Jernström and Olsson 1997), 564mL (British women, average 31 years: Hussain et al. 1999), to as high as 678mL (British women, average age 57 years: Scutt et al. 1997).

The glandular tissue of the breast is divided into fifteen to twenty lobes (Tortora and Grabowski 2003, Figure 1.1). The tissue has a complex branching structure (Levin 2006). Each lobe is divided into lobules and then alveoli which are embedded in the connective tissue (Tortora and Grabowski 2003). Individuals vary in breast size, but

also in the percentage of each breast that is made of glandular rather than adipose tissue (“glandularity”). Radiographic studies have estimated 48% glandularity in a Malaysian population (Jamal et al. 2004) while two German samples gave results of 43% and 35% glandular tissue (Klein et al. 1997). This ratio is not static: for example glandularity increases during pregnancy (Jones and Spencer 2007). It is unclear whether the large variation in overall breast size seen in women results in variation in the amount of milk-producing epithelial tissue (Levin 2006), but the variation seems to have no effect on overall milk production.

Nipple Complex

Nipples and accompanying areolae are present in males and females, although only females lactate (except under pathological conditions). Areolae are distinguished from the rest of the breast by their ridged epidermis and connective tissue, and by their pigmentation, which is due to oestrogen sensitive melanocytes (Levin 2006). Because of their hormonal sensitivity, the areolae gradually darken as an individual ages, and darkens even further during pregnancy (Garn et al. 1956; Pawson and Petrakis 1975). Pawson (1975) also found a non-significant trend towards the areola being darker in the days before menstruation, which coincides with a small peak in estrogens and a larger peak in progesterone (Tortora and Grabowski 2003).

The fatty structure of the breast

Breast size varies between individual women. This is at least partially determined by the amount of adipose tissue in each breast which varies between and within individuals (Katch et al. 1980). Katch (1980) estimated that 3.5% of overall reserves of body fat are carried in the breasts, though this figure varies from woman to woman, even when accounting for overall level of body fat. Anecdotal evidence also suggests that within individuals, the fat carried in the breast is sensitive to overall fat levels.

Figure 1.1. The structure of the human breast. Author's drawing from Tortora and Grabowski 2003

Development

The precocious development of the breast in humans is another feature of interest.

Females of other primate species do not develop breasts during puberty, instead development occurs during pregnancy (Levin 2006). The breast tissue of boys and girls is morphologically identical until the onset of puberty (Levin 2006). At this point, changes in circulating hormones, especially estrogens, result in the deposition of fat in the breasts and gluteo-femoral region (Dixson 2009) and triggers the first stages of glandular development (Levin 2006). The nipple/areola complex also

changes with the onset of puberty. In the first stage of development, Tanner's stage 2, the breast and areola enlarge slightly (Tanner 1978). In stage 4, the areola develops a slightly raised surface; this state persists until stage 5 in some women, and indefinitely in others (Tanner 1978).

There is evidence to suggest that these processes are triggered by available fat levels rather than simply starting at a specific age. Historical evidence shows a steady fall in the age of menarche (first menstruation is a clear sign of puberty) since the Industrial Revolution, perhaps reflecting increased food supply (Kaplowitz 2008). A cross-sectional study by Kaplowitz (2008) suggested that obesity in American children may be promoting earlier puberty rather than the other way around.

Even after breast growth and development is complete, the breast tissue is very active over the course of the human menstrual cycle, varying in levels of cell division, cell death and differentiation (Ramakrishnan et al. 2002). These processes result in a noticeable change in volume over the month, which Hussain et al. (1999) recorded as 92mL on average, or 13% of the overall volume. The peak volume is seen in the luteal phase, shortly before menstruation (Hussain et al. 1999).

The final stage of breast development occurs during pregnancy and is associated with an increase in breast volume (Jones and Spencer 2007). Mammogenesis occurs early in pregnancy and is physiologically similar to the changes occurring during the menstrual cycle, resulting in an enlargement of the breast (Jones and Spencer 2007). Lactogenesis starts mid pregnancy but physiological changes continue until a few days after birth (Jones and Spencer 2007). After lactation ends breast size reduces, but ptosis is often greater than before pregnancy. During menopause, the change in

hormone profile results in a change in the adipose tissue deposition in the breast, and it shrinks and droops (Gallup 1982).

Evolution of the breast

Phylogenetic history

As soft tissues do not fossilise, it is unclear when in human phylogeny the breast as it exists today first developed. Thus its development is poorly understood. However, the breast is generally thought to have developed early in the genus *Homo* (Pawlowski 1999). The post-cranial anatomy of some of these hominids is very similar to that of a modern human, and their levels of sexual dimorphism are thought to be similar (the males of both modern humans and *Homo erectus* are larger by a factor of 1.2) (Dixson 2009).

Subcutaneous levels of fat are also thought to have increased early in the genus *Homo* (Pawlowski 1999). Pawlowski (1999) suggested that the cool night temperatures in the Pleistocene open savannah/desert as selecting for extra insulation and storage of calories to benefit both mother and infant. The overall increase in subcutaneous fat stores may also have been related to the changing habitat these species experienced with greater seasonality than previously experienced and selection for greater labile fat stores (Arieli 2004).

The breast does not exist independent of other traits. Women carry relatively more fat than men. Overall, fat constitutes approximately 40% of a human female's weight; in comparison, a human male is 28% fat (Clarys et al. 1984). This fat is deposited in the breast, the hips, buttocks and thighs – this is known as the “gynoid fat distribution” (Dixson 2009). Fat deposition in the gynoid pattern avoids interference with thermoregulation or movement, which an all-over storage pattern may have caused.

The gynoid distribution of gluteo-femoral fat likely developed together with breasts as both respond to oestrogen and increasing fat levels. Both natural selection and the more specific mechanism of sexual selection are likely to be responsible for these patterns.

Natural selection

A wide variety of mechanisms have been suggested to explain why human breasts are enlarged with fatty tissue. The first set examines how the enlarged breast may be involved in infant care. Some have hypothesised that the enlarged breast aids in nursing from the lap (Anderson 1988) or hip (Leblanc and Barnes 1974). However, if such advantage exists, one would expect that larger breasts would be more widespread. Anderson's (1988) theory that adipose tissue helps warm the milk in the absence of fur likewise would suggest all breasts should be large. Harlow and Suomi (1970) demonstrated that a soft surface was preferred by infant monkeys and Smith (1986) argued that this suggests breasts act to comfort the human infant in contrast to the alternative of unpadded ribs. None of these theories explain why breasts should develop early in humans, at puberty instead of during pregnancy.

Some researchers focus on the temperature-regulating effects of breast fat. Einon (2007) hypothesised that the breast may be an expression of Bergman and Allen's rules, focusing on the heat stress early humans experienced in Africa. In this view, the breast is a kind of "cooling fin", to prevent the damage to foetal development caused by extreme heat (Einon 2007). She suggested that African women should have larger breasts than European women and that South-East Asian women (whose ancestors spent considerable time in sub-arctic regions) should have much smaller breasts (Einon 2007). However, the only evidence that she gathered to support this argument was the cup size of 100 female students in Britain and their ethnic origins; whether African,

South Asian, South East Asian or European. “Cup size” is a convention used in correct bra fitting and describes the difference between the torso circumference under the breast and over the largest point of the breast; a difference of less than two inches is an “A” cup, less than four inches is a “B” cup and so on (Einon 2007). This methodology fails to take into account that breast size is closely correlated to weight scaled for height (Rilling et al. 2009), that many women wear incorrectly fitted bras (Greenbaum et al. 2003) and so likely mischaracterised the breast sizes in her sample, and ignores the likelihood of mixed ancestry in study subjects.

Anderson (1988) suggested that breast tissue is important in hormonal homeostasis. The adipose tissue in breasts, and that in the abdomen, is important in transforming androgens to estrogens (Anderson 1988). Thus the inter-individual differences in breast development may be in response to variation in internal androgen levels, enlarging to accommodate higher levels of androgens in some women (Anderson 1988).

The breast and sexual selection

Fisher (1930) argued that features might be sexually selected if they meet certain criteria. He suggests that these criteria be that the features are effective as ornaments, that they are paraded conspicuously, that they seem to serve no function, and that they are at their fullest development when seeking a mate (Fisher 1930). However, as features may be acted on by sexual and natural selection simultaneously, the possible functions of the human breast need not necessarily eliminate it from consideration as a sexually selected trait. Before discussing the other factors Fisher highlighted, some discussion of the mechanisms of sexual selection is warranted.

Mechanisms of sexual selection

Intra-sexual selection is competition between members of one sex for access to the other; because it is usually the males competing in this way, it is also called male competition (Darwin 1874). In inter-sexual selection, members of one sex (usually the males) develop secondary sexual adornments and displays in order to attract the opposite sex; this mechanism is often called female choice (Darwin 1874).

Intra-sexual vs inter-sexual selection

Male intra-sexual competition takes a wide variety of forms. Emlen and Oring (1977) explained such competition as attempts to monopolise access to mates, either by controlling the females directly or by controlling resources they need. In some mating systems, males compete to control the breeding territory and fight between themselves for the right to do so (Emlen and Oring 1977). For instance, male pinnipeds compete vigorously to control areas where females will come ashore to give birth and then re-mate (Bartholomew 1970). This appears to have selected for large body size, enlarged canines and intra-sexual aggression in males (Bartholomew 1970). In other systems, male intra-sexual competition is more diffuse and males compete to attract females. Birdsong is an example of males competing but without necessarily engaging in physical interaction; Catchpole (1980) showed that male sedge warblers with more complex songs are paired earlier in the season, which is a good proxy for reproductive success. The second stage of sexual selection occurs when male competition has demonstrated the quality of available males, and female mate choice occurs.

Females may not necessarily choose the male who has “won” the inter-male competition. For example, male chimpanzees are very sexually aggressive but females often ignore courtship attempts or try to avoid mating with particular males, while at other times choosing to go on a “consortship” with males other than the alpha

(Goodall 1986). At Gombe, the practical ability of females to avoid mating was questionable (Goodall 1986), however in the Arnhem colony females were in much more control of their own mating and regularly refused males (de Waal 1982). Other species use “cryptic female choice” mechanisms that act after mating (Eberhard 1996). Females exerting cryptic female choice can prevent conception (for example in the lizard *Anolis carolinensis*) or selectively abort pregnancies (the so-called “Bruce effect”, seen in various groups of rodents) (Eberhard 1996).

This part of the process is also known as inter-sexual competition. That is because the two sexes have conflicting aims which each are trying to achieve with mating (“sexual conflict”, for a review see Chapman et al. 2003). From a male perspective, any mating increases their reproductive success relative to not mating, hence their enthusiasm.

Females, on the other hand, generally have more limited chances for reproduction and are more likely to exert stringent mate choice.

Differential Parental Investment

The pattern of male competition and female choice is explained by the different levels of investment each sex puts into reproduction (Trivers 1972). Trivers defined parental investment as any energy spent on one offspring which cannot be spent on future offspring (1972). The differences between the sexes begins at anisogamy – the different size of male and female gametes (Trivers 1972). Female gametes carry nutrients and tend to be large; the eggs of birds and reptiles are the extreme example. Male gametes, in contrast, are small and produced in great numbers (Trivers 1972). Even if parental investment ends at conception, females will usually have invested more in the offspring than males. Care often continues well past conception and takes a variety of forms: incubation, gestation, lactation, protection from danger, provisioning and care are all usually provided by the female (Kokko and Jennions

2008). Some of that investment also takes the form of time – female mammals invest relatively long periods of time in reproductive processes.

This differential in parental investment usually results in greater variability in male reproductive success than in females (Shuster and Wade 2003). The limited sex (usually males) reproduces as often as possible, while the limiting sex (usually females) is then in the position of ensuring the greatest possible return on their investment by choosing the best possible mate according to their own criteria.

Another example of this maximisation of reproductive success is seen in the Trivers-Willard hypothesis (Trivers and Willard 1973). The variation in a son's reproductive success is partially determined by how much a mother can invest in him, while the reproductive success of daughters is generally more stable (Trivers and Willard 1973). Both sexes have the same average reproductive success (Shuster and Wade 2003). Thus a female could improve her reproductive success by producing average daughters in preference to poor sons, or good sons in preference to either (Trivers and Willard 1973). In practice, this results in high production of males under good reproductive conditions and more females in poor conditions (for a discussion of possible mechanism and meta-analysis see Cameron 2004).

Types of Sexually Selected Traits

Darwin never fully elucidated what made an individual more attractive to members of the opposite sex, but made extensive lists of the wide variety of “beautiful” traits (Darwin 1874). Among his examples, he described the complex plumage of birds and songs or special ornaments, such as those of peacocks (Darwin 1874). Modern research has confirmed Darwin's ideas; the reproductive success of male peafowl is closely correlated to the size of his train of feathers (Petrie and Williams 1993).

Fisher argued that sexually selected features can develop extensively based only on a small initial reproductive advantage conferred by the trait (Fisher 1930). So long as fathers can pass on an advantage in having the trait and mothers can pass on an advantage in preferring it, the trait will develop by “runaway” selection (Fisher 1930). The initial trait need not be a true indicator of fitness - in fact some studies have reported preference for completely artificial traits such as marking bands on zebra finches (Burley et al. 1982).

“Good genes” features are thought to indicate high heritable fitness, while “compatible genes” signals are thought to indicate high-fitness combinations of genes (Neff and Pitcher 2005). Zahavi (1975) moved the emphasis to the handicap that the sexually selected feature imposes on the individual – the bigger the handicap, the “better” the individual must have been to withstand it. Under this theory, that all such signals must be honest – a poor quality individual cannot maintain them (Zahavi 1975). Another honest signalling mechanism is the parasite resistance mechanism of Hamilton and Zuk (1982). Their theory suggests that the higher the parasite load on the species, the greater the gain in choosing a genetically fit mate and the stronger the selection for clear signals of this fitness – sexually selected features (Hamilton and Zuk 1982).

These mechanisms are not mutually exclusive, which makes determining which may be acting at any given time complex. Determining which may have acted in the development and maintenance of human breasts is beyond the scope of this thesis. However, a discussion of the role of sexual selection on the specific development of the breast is in order.

The breast as a sexually attractive feature

The breast has traditionally been thought of as a mate attraction feature, although this attitude has been criticised as being Eurocentric (Anderson 1988). However, an international survey of sexual behaviour illustrated that breast stimulation was widespread as part of courtship or pre-coital activity (Ford and Beach 1952). This included many cultures in which the breast is habitually unclothed (Ford and Beach 1952). Breasts are also widely considered an aspect of sexual attractiveness; Ford and Beach (1952) for example recorded that two cultures prefer “upright, hemispherical breasts”, two prefer “long and pendulous breasts” and a further nine are reputed to prefer “large breasts”. A series of international surveys has shown that female breasts are important in ratings of attractiveness (in Israel and the U.S.A.: Gitter et al. 1983; in Vienna and the U.S.A.: Thornhill and Grammer 1999; in Britain and South Africa: Swami et al. 2009; these studies are discussed further below and in Chapter Five).

Human biology and reversal of the sexual selection roles

As discussed earlier, sexual selection usually acts more strongly on males than on females. Breasts are physiologically expensive; besides the adipose tissue carried within them (Katch et al. 1980) they can interfere with effective movement and are often large enough to cause back and neck pain (Chadbourne et al. 2001).

“Expensive” signals are expected to be honest and to carry information of high importance; expensive but trivial signals are safe to ignore, and dishonest signals are unlikely to convey enough fitness benefit to encourage their existence (Champion de Crespigny and Hosken 2007). The evidence suggests that breasts are sexually selected and are used by males to choose mates, which constitutes a partial reversal of the usual pattern of sexual selection.

This reversal is not unprecedented; in many species the reproductive success of females requires high levels of male parental investment (Clutton-Brock 1991), and in some of these species the female is more active in seeking a mate than the male (Clutton-Brock and Vincent 1991). The human situation seems to be an intermediate example; both sexes seek to optimise their reproductive success by choosing the best possible mate, and both parents often provide considerable care. However, the question arises as to what about human ecology requires a male to choose his mate carefully and what signals might he be using to make this choice. Trivers' analysis of parental care suggests that male selectivity in mates may be related to the high levels of male parental care in humans (Trivers 1972).

Human infants are extremely dependent on adults for care, and for much longer than in many other species. However, human infants grow extremely fast, especially their brains (Tanner 1978). The last few weeks of growth before birth appears to be actively slowed to allow for an easier parturition, and the infant spends the first few weeks "catching up" (Tanner 1978). Human lactation is best suited for constant small feeds, rather than a few large ones – the milk is relatively high protein (to aid the high levels of growth) and storage in the breast inhibits lactation (Anderson 1988).

Childcare is thus an intensive and extensive exercise, and there is enormous scope for paternal care to significantly impact the reproductive outcomes of women.

These factors have led to a model of male provisioning in humans (for example Lovejoy 1981). However, the real world data are equivocal on this matter. Studies of hunter-gatherer groups report that in some cultures a husband brings in a significant fraction of calories for the family group, while in others a husband contributes less frequently (Marlowe 2001). The models also assume that mothers are entirely

occupied with the infant and reliant on a providing male (Lovejoy 1981). However, historically and in extant hunter-gatherer groups, humans have tended to live in extended family groups with ample opportunities for kin selection from relatives such as grandmothers and older siblings.

Burley highlighted another problem with this theory. If females are incapable of raising a child alone, then biparental care will evolve as a function of natural selection; males who do not care for their young will have no reproductive success (Burley 1979). Despite issues with the provisioning theory, human males can and often do invest a lot in their young, compared to other mammals, and this investment has a significant impact on offspring survival (Geary 2000; Marlowe 2001).

Human males are therefore expected to be more selective about their partners than non-investing species. Breasts might act as sexual signals and provide males with information about the mate quality of their potential partner, allowing them to invest their time and resources to greatest effect. Regardless of the mechanism responsible for the evolution of breasts, the question remains: why and how did breasts first become a mate attractant? After all, in other mammal species, an enlarged mammary gland is a sign of temporary infertility – pregnancy and lactation (Ford and Beach 1952). It is not at all clear how a sexual attraction to such a signal could develop.

The origin of the mate attraction function of breasts

The breast has been linked to the perceived loss of a defined and externally detectable fertile period in the human reproductive cycle, although whether such “loss” has occurred is disputed (Dixson 2009). In the absence of a clear external signal of ovulation, some have argued that breasts signal whether a woman is sexually mature and potentially ovulating – breasts that are underdeveloped due to being pre-pubertal

or post-menopausal would be a sign of infertility (Gallup 1982; Marlowe 1998). This distinction would be easier for males to make against a background of larger breasts, thus also promoting the enlargement of breasts (Gallup 1982).

There is some evidence that large breasts do honestly signal reproductive potential. A study of Polish women indicated that women with larger breasts and smaller waist-to-hip ratios had higher circulating levels of 17- β -oestradiol and progesterone (Jasińska et al. 2004). Jasińska (2004) cautiously predicts that the difference in hormone levels may indicate a three-fold higher chance of pregnancy, based on conception rates in another sample (Lipson and Ellison 1996).

Less well supported theories abound. For example, Miller (1995) posited that dominant males found enlarged breasts unattractive as they signalled the infertile stages of pregnancy and lactation. While the females were unattractive to the dominant male, the sub-dominant males took the opportunity to provision and befriend them (Miller 1995). Provisioned females had better reproductive rates, and provisioning males increased their chances of being the father of the next child (Miller 1995). The theory fails to explain why the dominant male continued to use this strategy when it was not generating good reproductive success, nor what prevented this male from monopolising the females as soon as they had finished lactating.

A recurring theme in discussions of the role of breasts as sexual signals is that they indicate ability to nurture an infant. Large breasts could indicate that the woman is energetically competent, and has the resources to maintain a pregnancy (Caro 1987). Gallup also noted that the breasts of a habitually undernourished woman tend to be

under-developed (1982). Large breasts might also be associated in the minds of males with better lactational ability, although no link has ever been established. Milk production would presumably be strenuously naturally selected to optimum levels, regardless of breast size or male preference.

While breast size has attracted a lot of attention in publications of attractiveness studies, other aspects of breast morphology might also potentially transmit information to males. The nipple and areola are good candidates for signals; they are sensitive to oestrogen and respond by changing colour and size during puberty, pregnancy (Garn et al. 1956) and during the menstrual cycle (Pawson and Petrakis 1975). The majority of human evolution has occurred in the absence of clothing, and therefore this signal would have been quite visible.

Fluctuating asymmetry

Fluctuating asymmetry is a type of developmental instability; it is a measure of how much an individual varies from the typical pattern of bilateral symmetry (Møller 1999). Fluctuations are thought to represent inability to tolerate stressors, either genetic or environmental (Møller and Pomiankowski 1993). Sexual selection is considered to be closely related to fluctuating asymmetry and the predicted relationship is that less symmetrical individuals will be less favoured than symmetrical individuals (Thornhill and Møller 1998). This idea has been reviewed in relation to the size of traits (Thornhill and Møller 1998) and fecundity, growth and survival (Møller 1999). Both studies found that overall, fluctuating asymmetry is a robust measure of fitness (Thornhill and Møller 1998; Møller 1999).

Fluctuating asymmetry has also been studied in breasts as a measure of fitness.

Breasts should be especially prone to fluctuating asymmetry because they develop

quickly during a potentially stressful time in an individual's life (Manning et al. 1997) and because secondary sexual traits have, on average, higher levels of fluctuating asymmetry (Thornhill and Møller 1998). Anecdotally, breast asymmetry is considered to be very common. Studies have shown that asymmetry in breasts is substantial compared to levels found in other morphological characters in humans, which tend to be within 2% (Auerbach and Ruff 2006; Brown et al. 2008). In two samples – from America and Spain - breast asymmetry (both relative and absolute) increased with breast size and approached 5% (Møller et al. 1995). However, it should be noted that the American sample was from women visiting a plastic surgeon, and hence was unlikely to be a fully representative sample of the population, and that each sample used a different one dimensional measurement to approximate a three dimensional feature (Møller et al. 1995). The Mexican sample measured the circumference of the breast from sternum to armpit, while the American sample used the distance from supra-sternal notch to nipple on a photograph (Møller et al. 1995). Another, although smaller, study measured the actual volume of the breast and found a fluctuating asymmetry of approximately 7%, or 40mL (Hussain et al. 1999).

Research has linked fluctuating asymmetry in breasts to several fitness measures. Møller and colleagues (1995) evaluated the lifetime fecundity of the women in their sample and found that mothers had significantly less fluctuating asymmetry than non-mothers. Another study showed that more asymmetrical women were less likely to marry, likely to have less children and to have them later in life (Manning et al. 1997). A study of breast cancer patients (Scutt et al. 1997) showed that, as a group, their fluctuating asymmetry levels were significantly larger than those of an age-matched group without breast cancer. This discrepancy was not caused by the volume of the tumour itself (Scutt et al. 1997).

Manning and others (1997) have proposed a mechanism to link breast asymmetry and fitness, namely that estrogens compromise immunocompetence; larger breasts are related to higher oestrogen levels and also to higher levels of asymmetry. Whether or not this theory proves to be right, it seems that fluctuating asymmetry is a strong indicator of fitness.

Studies have shown that humans are sensitive to asymmetry levels in many traits. Little and colleagues (2007) showed that both Hadza hunter-gatherers and subjects from the UK preferred symmetrized photographs of human faces over the original images. The fact that the Hadza had a stronger preference for symmetry is theorised to be a consequence of stronger pathogen pressure in the African group. Tovée's work (2000) asked males to choose between symmetrized and original photographs of the entire female body and found a small but significant preference for the symmetrized versions. Singh (1995) investigated the relative attractiveness of figures while altering levels of breast asymmetry and waist-to-hip ratios and found that breast asymmetry was a significant factor in judgments of attractiveness and desirability for relationships.

Methods used to investigate human attractiveness and sexual selection

Attractiveness studies

The earliest attractiveness study seems to be that of Wiggins et al. (1968). This early study used 15 images of a female silhouette which was systematically varied in its bust size, buttock size and leg thickness. Wiggins and colleagues employed a paired-comparison methodology; each image was compared to every other image (105 pairs).

This study was actually designed to test how personality traits might be related to attractiveness ratings (Wiggins et al. 1968).

Attractiveness studies have examined a huge variety of sexually selected features of humans, both male and female. When looking at the female body, the major features being examined are the waist-to-hip ratio (Singh 1995; Furnham et al. 1998; Wetsman and Marlowe 1999; Marlowe and Wetsman 2001), a variety of measures of weight (Horvath 1979; Furnham and Alibhai 1983; Singh and Young 1995), breast symmetry and breast size.

Studies of breast size have produced a range of contradictory results. Some report that large breasts are preferred (Gitter et al. 1983; Furnham et al. 1990; Singh and Young 1995); others report a preference for small breast sizes (Thornhill and Grammer 1999; Furnham and Swami 2007). However, it is important to note that as well as having different samples, many of these studies used different images. Because of the range of methods used to create the images, and the different definitions of “large” and “small” breasts, direct comparisons between studies are problematic. The impact of using different types of images is the topic of Chapter Five of this thesis.

The usual methodology employed in research into human attractiveness is to recruit university students to participate (for example, the following studies used exclusively undergraduate students: Wiggins et al. 1968; Beck et al. 1976; Horvath 1981; Thompson and Tantleff 1992; Furnham et al. 2006). This is a convenient sample for researchers; students can be easily recruited and they often already have an interest in the topic. There is a perennial dispute as to whether university students are an accurate representation of the population as a whole, as students have a tendency to be

above average socio-economic status, limited age range and (by definition) well educated. A second-order meta-analysis suggested that this tends to result in more homogenous results than a broader sample (Peterson 2001).

The logistics of measuring attractiveness in these studies are quite standardised. A set of images is generated varying in specific traits. Images are shown to large numbers of recruited participants who rate them on a variety of measures. The method of displaying the images varies – sometimes a booklet is used (as in Singh 1995), sometimes an eyetracker (for example Dixon et al. 2009) but projected images are cheap to produce and easy to use (for example Krantz et al. 1997). Rating systems vary widely, but individual authors tend to use one system consistently. Singh favours a multi-question, 20 point Likert scale system, where participants rate each image independently on a variety of traits (Singh 1995). Others ask participants to compare each image to a standard (Krantz et al. 1997) or other images within the set (Wiggins et al. 1968). Occasionally, rather than experimental modifications, images of real people are compared without adjusting any biometric values, although this technique only allows correlations rather than a more detailed analysis (Rilling et al. 2009). Regardless of methodology, the overall aim is to elucidate how changing traits such as shape and size influence perceptions, and how these perceptions might inform mate choice in humans.

Photo-manipulation

Images used in attractiveness research vary in the amount of detail they convey. At one end of the spectrum is Wiggins's (1968) work, using a set of completely black silhouettes. A variety of line drawings has also been used, with varying levels of realism. The line drawings developed by Singh (1993) have been reused and altered on several occasions. (The impact of the type of image in attractiveness studies is

discussed in more detail in Chapter Five.) Occasionally, photographs have been used, but until recently the technology to alter them was cumbersome (for example the techniques described in Alicke et al. 1986). However, recent technological advances have made photo manipulation available on most computers and such techniques have been used in a variety of studies (face morphology; Law-Smith et al. 2006; waist-to-hip ratios; Dixon et al. 2009).

Photo manipulation allows the experimenter to control all aspects of the image, from the background colour to the skin tone of the subject. Experimental changes can be subtle, or colour based. This is more difficult to achieve when using drawings. Photo manipulation also allows images of real people to be used in these attractiveness studies, rather than images that are necessarily stylised.

Aims and structure of this thesis

This thesis represents an extension of the research on sexual selection and its impact on breast size and morphology. The thesis aims to evaluate the importance of different aspects of breast morphology and their interactions on how observers make judgements about images. This first chapter has been a discussion of the rationale and history of such studies. The second chapter discusses the methodology of the two independent studies that make up the bulk of this thesis. I discuss the methods of photo manipulation, participant recruitment, and study presentation. The first study (results in Chapter Three) is an analysis of the interaction between breast size and areola colour, in relation to attractiveness, health, nurturance and sexual maturity ratings, and on estimates of age. The stimulus images were modelled by systematically changing the breast size and areola pigmentation on an image of a young woman. Chapter Four details the results of the second major study, on the effect on attractiveness and health ratings of systematically altering breast asymmetry.

The fifth Chapter is a smaller, pilot study, investigating the impact of the type of images being used in attractiveness studies. The Appendices contain an example of the response forms used, and summaries of the raw data gathered in all three studies.

Chapter 2 Materials and Methods

Development of images

Study 1: The impact of breast size and areola pigmentation on perceptions of attractiveness, health, nurturance, sexual maturity and age.

This study used an image taken from a book of nude photographs for use in life drawings (Simblet 2001). The image was scanned in order to make digital copies, which were then systematically altered in Photoshop Version 7.0 to create the stimulus instrument. This stimulus instrument was shown to the sample population and their ratings of it were used to determine the impact of two factors – the size of the breast and the pigmentation of the areola – on perceptions of a variety of traits.

The original image is of a young, thin, pale-skinned Caucasian woman in a 3/4 or oblique pose; she is half turned towards the camera (Figure 2.1). For use in this study, the image was cropped at the waist and mouth to avoid the potential for facial structure or waist-to hip-ratio to influence results, while still keeping the breasts in an understandable context.

Figure 2.1. The original image used for the breast size and areola colour study

Breast size modifications

Four breast sizes were modelled in this study; a completely flat chest (referred to throughout this thesis as 0%); the original breast reduced to 80% of original size (80%); the original breast size (100%); the original breast modified to be 120% the original size (120%). These four levels of breast size were used in the analysis of variance as the first factor.

The breasts were systematically altered to achieve the different breast volumes (Figure 2.2). The nipple and areola region was adjusted separately from the volume of the breast. First, the section of the image containing the breast was separated from the rest of the image. As the woman was posed obliquely, each breast was viewed from a different angle and so altered independently. The separate images of the breasts were enlarged or reduced as required. Each new image of the breast was then returned to a copy of the original image, and any clear join marks or incongruous shadows corrected for. This created four images differing in the size of the breast (Figure 2.3b, e, h and k).

Areola pigmentation modification

The colour change of the areola was dealt with in a similar fashion as the breast size modifications. Three levels of areola pigmentation were used - a lightened version, the original and a dark version. Using photo-manipulation tools, the original areolae were removed from the image and systematically lightened or darkened (see Figure 2.2). Each of the three areola colours were then applied to each of the four breast size images to create the final twelve images (seen in Figure 2.3).

Figure 2.2. The process of modelling the 12 images using four breast sizes and three areola colour schemes

Step 1: The highlighted area was cut out

Step 2: Original breast is modified to create 4 sizes

Step 3: The areola area was cut out and recoloured to create three areola colours

Step 4: All 12 possible combinations were made and used in stimulus instrument.

Figure 2.3. The twelve images used the stimulus instrument for breast size and areola colour study

Figure 2.3 Continued

Study 2: The impact of breast asymmetry in two dimensions on perceptions of attractiveness and health.

The source image for the second study was also taken from Simblet (2001); this image has previously been used as a source image by Dixon et al. (2009). This image is of young, thin woman with tanned skin, posed facing the camera (Figure 2.4). For the purposes of this study, the image was cropped at the pelvis but the head was retained.

Figure 2.4. The original image used for the breast asymmetry study.

This image was scanned and modified with Photoshop Version 7.0. Eighteen images were produced in total (the process is shown in Figure 2.5). The original image and a symmetrised version of it formed the two controls. The breast asymmetry was systematically altered in two ways. The volume of one breast was increased in four incremental steps to create one set. The position of the posterior margin was incrementally adjusted to create another four image set. Finally, the mirror images of these modifications were produced.

Controls

The first control was the original, unaltered image (Figure 2.4). The second control was the original image modified to have symmetrical breasts. Making the entire image symmetrical was not desirable, as this would have altered many other factors known to alter attractiveness, such as waist-hip ratio (Singh 1995) and can create

abnormal chimeric images (Rhodes et al. 1998). To combat these issues, only the breasts and arms of the original image were made symmetrical. The arm was included as a practical measure, as the breast overlaps the arm from the front and copying the arm over as well reduced the need for touchups later in the process. Previous research has indicated that the arms are rarely looked at during determinations of attractiveness (Dixson et al. 2009). The area that was symmetrised is highlighted on Figure 2.5. This second control was used as the basis for all further modifications.

Asymmetry in breast size

The aim of the first set of modifications was to model the impact of asymmetry in breast size on attractiveness and health ratings. The area of the image containing the right breast (from the viewer's perspective) was systematically enlarged (see Figure 2.5). The four levels of enlargement were 102.5%, 105%, 107.5%, and 110% of the original size, while maintaining the original nipple and areola size. (Figure 2.6c, d, e f).

Asymmetry in the position of the breast

The second set of modifications aimed to assess the impact on attractiveness and health ratings of asymmetries in the apparent position or ptosis (droop) of the breast (Figure 2.5). Four levels of positional modification were made by systematically lowering the posterior margin of the right breast (Figure 2.6k, l, m, and n). The nipple/areola complex stayed the same distance from this lower margin, which avoided the breast appearing larger as well as lower. The four adjustments were 1%, 2%, 3% and 4% of the overall length of the image. The most extreme level of asymmetry is within normal ranges of asymmetry in American women (Møller et al. 1995).

Figure 2.5. The process of modifying the image for the stimulus instrument

Step 1: Original Image is made into Symmetrical Image

Step 2: Four modifications of the size of her right breast are made.

Illustration shows 110% modification

Step 3: Four modifications on the position of her right breast.

Illustration shows 4% modification

Step 4: Mirror Image of each image generated

(g) Left Volume 102.5%	(h) Left Volume 105%

(i) Left Volume 107.5%	(j) Left Volume 110%

(k) Right Position 1%	(l) Right Position 2%

Figure 2.6 Continued	

(m) Right Position 3%	(n) Right Position 4%

(o) Left Position 1%	(p) Left Position 2%

(q) Left Position 3%	(r) Left Position 4%

Figure 2.6 Continued	

Asymmetry on the right side of the body vs the left side of the body

Studies have shown that there is a reliable tendency to attend more strongly to the left side of objects and images (Charles et al. 2007; Rhode and Elias 2007), a phenomenon called “pseudoneglect” (Bowers and Heilman 1980). To assess the potential impact of pseudoneglect on this experiment a second set of images was generated (Figure 2.5). Each of the eight altered images (Figure 2.6c,d,e,f and k,l, m and n) were inverted left-to-right to create their mirror image. This created images in Figure 2.6g, h, i, j and o, p, q and r. The mirror image of the model’s face was noticeably different from the original and cues to the fact that some of the images were mirror images of the others was undesirable, so the unaltered head was replaced on all mirror-flipped images. Again, any problems with obvious joining lines and shadows were smoothed out.

Procedure

Presentation

Each set of images was presented in random order as a Microsoft Powerpoint presentation. Each image was centred in the slide, with a pale background and had a number clearly identifying its sequence in the presentation. This number was to help participants keep track of which image they were viewing but bore no relationship to the alterations done.

Recruitment

100 males and 100 females were recruited for each study. As datasheets were sometimes found to be unusable during data entry, recruitment continued until 100 males and 100 females submitted usable results. Two methods of recruitment were used. The first method of recruitment was approaching students in undergraduate biology and computing classes at Victoria University of Wellington. These participants were shown the images on the main overhead projector screen in the

lecture hall. Participants recruited from undergraduate student populations tend to be homogenous in their ethnicity, age and socio-economic status; this is a perennial criticism of research using them as the subjects (for an example of discussions on this see Peterson 2001). To combat this, participants were also recruited opportunistically via social contacts. These participants were from a variety of socio-economic and employment status' and had a wider age range. Opportunistically recruited participants viewed the stimulus instrument on a laptop screen, either singly or in small groups.

All participants were given the same briefing as part of both recruitment methods, either verbally or in written form. The briefing informed the participants that they would be viewing nude female torsos. Participants were informed that they could excuse themselves from the study at any point and how the data would be processed, and that their answers would remain anonymous. While they were not told the specific question that was being assessed, informal comments from participants indicated they detected the changes and deduced the question being asked within a few images.

Each participant was asked to fill out a brief demographic questionnaire. This asked their sex, age, ethnic identity (Pakeha/European, Maori, Other), NZ citizenship status and marital status (Single, De Facto, Married, Divorced/Separated). This was filled out during briefing. A copy of the questionnaire sheet is included in the Appendices (A1) and the answer sheet is shown for Study 1 (A2).

This research was approved by the Victoria University Human Ethics Committee.

Stimulus presentation

The rating (Likert) scales were explained, and participants were asked not to use fractions or ranges in their answers. They were also informed that each image was modified from the same original, and that all images were different. Lastly, participants were asked not to confer with each other until after the study was complete. At the end of the study, the participants were debriefed and questions about the methodology or theory could be asked.

Datasheets were discarded if the participant showed signs of not taking the study seriously, or if not all ratings for all images were entered and legible – in some instances, whole columns or rows were left blank, in other instances single points were missed. Data from the retained sheets were processed into a spreadsheet for storage and analysis.

In the study on breast size and areola pigmentation, each image was shown for twenty seconds. Participants were asked to rate the image on attractiveness, health, sexual maturity, how nurturing they thought the woman was, and also estimate her age. Twenty seconds was determined to be enough time to answer the questions.

For the study on breast asymmetry, each image was shown for only ten seconds. Participants were asked to rate on attractiveness and health only and so less time was required. The same rating system was used for both studies.

Rating scales

Attractiveness – Breast size/Areola Pigmentation and Symmetry Studies

Attraction is a core aspect of sexual selection theory; sexual selection occurs because members of one sex are preferentially attracted to members of the other (Fisher 1930).

Questions about attractiveness are often used in such studies (eg Horvath 1981; Furnham and Swami 2007; Swami et al. 2008). Participants in both studies were asked to rate the images in both studies for attractiveness. Both studies used the following Likert scale:

- 1 = Unattractive
- 2 = Slightly attractive
- 3 = Average
- 4 = Very attractive
- 5 = Extremely attractive

Health - Breast size/Areola Pigmentation and Symmetry Studies

Health was assessed because much of the theory of sexual selection is based on the proposition that attractive individuals are healthy individuals. Both the “good genes” (see discussion in Berry 2000) and “handicap principle” (Zahavi 1975) mechanisms are based on the idea that healthy individuals are desirable and sexual selection acts to emphasise this fact. Participants were also asked to rate each figure for health in both studies. The following Likert scale was used in both studies:

- 1 = Unhealthy
- 2 = Slightly healthy
- 3 = Healthy
- 4 = Very healthy
- 5 = Extremely healthy

Nurturing - Breast size/Areola Pigmentation Study

Many discussions concerning the effect of sexual selection on breast morphology are based on the idea that breasts advertise the ability of a woman to successfully raise an infant. While there is no known correlation between a woman’s breast size and her ability to lactate, one has often been assumed (see discussion in Caro 1987). This question evaluated the popular assumption that a woman bearing large breasts may be better able to nurture infants. Participants were asked to rate the images for nurturance only in the study on breast size and areola colouration, using the following Likert scale:

- 1 = Unnurturing
- 2 = Slightly nurturing
- 3 = Averagely nurturing
- 4 = Very nurturing
- 5 = Extremely nurturing

Sexual Maturity - Breast size/Areola Pigmentation Study

This scale was to assess how well breast morphology communicates the sexual maturity of the woman. As the systematic changes breast size and areola pigmentation mimic changes in a real breast during puberty and adult development, it was expected that this rating would also change systematically. Participants were asked to rate the image for sexual maturity using the following Likert scale:

- 1 = Preadolescent
- 2 = Adolescent
- 3 = Post adolescent
- 4 = Young adult
- 5 = Adult

Age of the woman – Breast size/Areola pigmentation Study

The participants in Study 1 were asked to estimate the age of the woman depicted in each image based on her breast morphology. This question was associated with the sexual maturity question to determine if they were consistently related to each other and whether perceived age was related to attractiveness. This question did not involve a rating scale – participants were asked to estimate age in years, and not give ranges.

Study Population

Study 1: Breast size and areola pigmentation

Thirty seven incomplete or incorrectly filled out forms were discarded. 200 participants (100 men and 100 women) were included in the analysis (Table 2.1). The high rate of single participants was probably related to the relatively young age group. Age varied significantly within these groups ($F_{(3,195)} = 45.56, p < 0.001$); as one would expect, the youngest group was single, followed by *de facto* then married, and the members of the divorced/separated group were the oldest.

156 participants described themselves as “Pakeha/European”; they had a mean age of $22.4 \pm 5.5^{\dagger}$ years. Of those who stated they were “Pakeha/European”, 147 participants identified themselves as New Zealand citizens, and nine did not. A further nine listed themselves as Maori, however data on tribal affiliation was not recorded. All those who identified as Maori also identified themselves as New Zealand citizens. Their mean age was 26.9 ± 8.67 years. Thirty-five participants listed themselves as “Other”; they had a mean age of 21.2 ± 2.3 . Twenty one “Others” listed themselves as New Zealand citizens, fourteen did not. Where a participant chose two options, they were coded as the non-Pakeha/European option, for ease of data processing.

Table 2.1. Demographic data for participants in Study 1 (breast size and areola pigmentation).

Demographic information of participants		
	Males	Females
<i>Age</i>		
Mean	23.22 ± 6.35	21.6 ± 3.89
Minimum-Maximum	17 – 59	17 – 50
<i>Ethnicity (n)</i>		
Pakeha/European	84	72
Maori	7	2
Other	9	26
<i>NZ Citizen (n)</i>		
Yes	96	81
No	4	19
<i>Marital Status (n)*</i>		
Single	80	85
De Facto	13	10
Married	6	3
Divorced/Separated	1	1

* some participants chose not to answer this question.

Study 2: Breast asymmetry

200 subjects also participated in this study – 100 men and 100 women (Table 2.2).

Eight datasheets were excluded as being incorrectly or incompletely filled out. As discussed above, the relatively young sample group probably contributed to the high fraction of single participants. Age varied significantly within these groups ($F_{(3,195)} =$

[†] Standard Deviation

31.15, $p < 0.001$); as one would expect, the single group was the youngest, followed in order by *de facto*, married and divorced/separated.

160 participants listed themselves as “Pakeha/European”; they had a mean age of 23.86 ± 8.7 years. Of this 160, 147 identified themselves as New Zealand citizens, and thirteen not. A further twelve listed themselves as both Maori and as New Zealand citizens. Their mean age was 21.6 ± 4.6 years. Twenty eight participants listed themselves as “Other”; they had a mean age of 22.35 ± 5.27 . Twenty two “Others” listed themselves as New Zealand citizens, eight did not.

Table 2.2. Demographic data for participants in Study 2 (breast asymmetry)

Demographic information of participants		
	Males	Females
<i>Age</i>		
Mean	22.74 ± 7.98	24.31 ± 8.21
Minimum-Maximum	16 – 60	18 – 70
<i>Ethnicity (n)</i>		
Pakeha/European	82	78
Maori	7	5
Other	11	17
<i>NZ Citizen (n)</i>		
Yes	91	90
No	9	10
<i>Marital Status (n)*</i>		
Single	83	73
De Facto	11	17
Married	5	9
Divorced/Separated	1	1

Analysis

Both studies were analysed in SPSS (version 17.0). Multi-way analysis of variances were performed with each modification type and sex of the participant as factors.

Statistical advice was sought and gratefully received from Barnaby Dixson. Because of the large numbers of analyses, the possibility of Type I errors was inflated. In an attempt to allow for this, alpha (α) was set conservatively. The null hypothesis was rejected for analyses when the p-values were 0.01 or less, although significance

values of under 0.05 were considered evidence of a trend. For the same reason, Scheffé paired-comparison tests were used; this test is relatively conservative.

An “analysis of variance” (or ANOVA) describes a statistical technique of determining whether the differences between groups are larger than the differences within such groups. A so-called “statistically significant difference” is one where the differences between the groups outweigh the differences within the groups. A one-way analysis compares the means when the groups are divided based on one factor, such as “extent of asymmetry” (in this study five options) or “sex of participant” (usually two options). A two-way analysis puts each value into two categories and compares each combination – for example men with each extent of asymmetry and women with each level of asymmetry, giving a total of 10 groups - and how the factors interact – do women react to asymmetry differently than men. A three-way analysis uses three factors and so on.

The assumptions of this form of analysis are that the samples are independent, have the same standard deviations as each other and are normally distributed (Wild and Seber 2000). Each dataset contains one judgement from one participant on one picture – comparisons are between the same participants making the same judgement on different images. Participants were instructed to make these judgements independently for each image and so the datasets are considered as independent as practically possible.

Violation of the assumption of same sized standard deviations is most likely to have its effects on the confidence intervals produced by an analysis of variance (Wild and Seber 2000) . Confidence intervals were not extensively used in this analysis, as

Scheffé tests have been used for the post-hoc comparisons. The means and standard deviations of the data for all studies are shown in Appendices A3, A4 and A5. Wild and Seber (2000) repeat the rule-of-thumb that confidence intervals are only likely to be adversely affected if the largest standard deviation is larger than twice the smallest. This requirement is satisfied, despite confidence intervals not being extensively used, in all data-sets except the age estimates and attractiveness ratings for the breast size and areola colouration study.

The Normality of the dataset is also an issue. While such scales are technically interval data, Likert-like scale have been used in this study to approximate a normal distribution – a point along a continuity from attractive to unattractive. However, other aspects of the data are reflective of a Normal distribution. The data have been compared to a Normal distribution using the P-P plot, where the expected cumulative probability is plotted against the actual cumulative probability. If these two fit closely, with no strong pattern in deviations from the fit, the data resembles a Normal distribution. Analysis of the data in this thesis show a good fit on the P-P plot, with the exception of some age estimate data from the breast-size and areola colouration data. The analysis of variance is also very robust to deviations from Normality, particularly when the sample sizes are the same (Wild and Seber 2000), as is the case in these analyses.

Another consideration is continuity with other analyses. Many of the prior studies have used ANOVA analyses on similar Likert-like data (for example: Thompson and Tantleff 1992; Singh 1995; Dixson et al. 2009). Maintaining continuity of analysis style makes comparisons with previous work easier. A final consideration is that there is no real way to run 3-way analyses with non-parametric analyses.

Study 1: Breast size and areola pigmentation

Each response variable was analysed using a three way analysis of variance using the repeated measures function. The analysis used a crossed design to analyse the impact of sex of the participant (2 levels), the size of the breasts in the image (4 levels) and the colour of the nipple/areola complex (3 levels). The two types of modification were investigated more closely with a separate ANOVA on each factor, followed by paired-comparison Scheffé tests. The Pearson correlation (r) was also calculated between all pairs of ratings. The means and standard deviations for each of the ratings for each of the images is in the Appendices (A3).

Study 2: Breast asymmetry

Both response variables were analysed separately with a four way analysis of variance using the repeated measures function. This analysis examined the impact of sex of the participant (2 levels), the type of modification made (2 levels), the extent of the modification (4 levels) and the bilateral orientation of the modifications (2 levels). To more closely examine the effects of the experimental modifications, independent analyses were performed on sub-sets of the images. Each experimental image was compared to its mirror-image. One-way ANOVA (accompanied by Scheffé tests) were used to test for the impact of systematic modifications in breast asymmetry, testing each type of asymmetry separately. Both controls were also compared to these systematically changed images. The Pearson correlation (r) was also calculated between the two ratings. The means and standard deviations for each of the ratings for each of the images is in the Appendices (A4).

Chapter 3 Results of Study 1: Breast Size and Areola Pigmentation

Three way analysis of five ratings

Attractiveness

An analysis of variance indicated that both breast size and areola colour influenced ratings of attractiveness. However, the sex of the participant had no significant effect ($p = 0.102$). Thus data from male and female participants have been pooled for further analysis. The three-way analysis of variance also indicated that breast size and areola colour had a significant interaction (Table 3.1).

Table 3.1. Results of three way analysis of variance for effect of participant sex (Sex), image breast size (Size) and image areola colouration (Colour) on attractiveness ratings.

	Degrees of Freedom	F statistic
Sex	1, 99	2.72
Size†	2.92, 254	610.77***
Colour†	2, 185.341	81.69***
Sex × Size†	2.53, 250	1.04
Sex × Colour	2, 198	0.220
Size × Colour†	4.22, 417.75	96.74***
Sex × Size × Colour†	4.39, 435.02	0.717

† = Greenhouse-Geisser correction applied to the degrees of freedom as the Mauchley's Test of Sphericity is significant for these tests.

*** = Significant at 0.001

Health

The analysis of health ratings gave the same pattern of results as the attractiveness ratings (Table 3.2). Again, the sex of the participant was not significant ($p = 0.34$) and data were pooled in all further analysis. Breast size and areola colour both influenced the health ratings of images. The only significant interaction was between breast size and areola colour.

Table 3.2 Results of three way analysis of variance for effect of participant sex (Sex), image breast size (Size) and image areola colouration (Colour) on health ratings.

	Degrees of Freedom		F statistic
Sex	1,	99	0.91
Size †	2.12,	209.52	237.32***
Colour †	1.78,	176.33	89.75***
Sex × Size†	2.32,	229.609	0.70
Sex × Colour	2,	198	0.14
Size × Colour†	4.92,	487.40	69.77***
Sex × Size × Colour†	4.50,	445.12	2.05

† = Greenhouse-Geisser correction applied to the degrees of freedom as the Mauchley's Test of Sphericity is significant for these tests.

*** = Significant at 0.001

Nurturance

The results of the three way analysis of variance showed that the sex of the participant was not a significant factor in nurturance ratings ($p = 0.193$) – the data for both sexes were therefore been combined for all further analyses. The two experimental modifications of breast size and areola colour impacted nurturance ratings (Table 3.3). The only significant interaction was between the two main effects – size and colour.

Table 3.3. Results of three way analysis of variance for effect of participant sex (Sex), image breast size (Size) and image areola colouration (Colour) on nurturance ratings.

	Degrees of Freedom		F statistic
Sex	1,	99	1.719
Size †	2.54,	251.10	834.49***
Colour †	1.89,	186.76	6.95**
Sex × Size	3,	297	1.89
Sex × Colour†	1.85,	183.46	1.07
Size × Colour†	4.95,	489.97	22.59***
Sex × Size × Colour†	4.66,	461.14	1.52

† = Greenhouse-Geisser correction applied to the degrees of freedom as the Mauchley's Test of Sphericity is significant for these tests.

** = Significant at 0.01

*** = Significant at 0.001

Sexual Maturity

The analysis of effects of breast size and areola colouration on sexual maturity ratings showed that the sex of the participant was not significant ($p = 0.791$, Table 3.4). The main effect of breast size was statistically significant, but the main effect of areola colour was not ($p = 0.459$). There was a significant interaction of breast size and areola colouration, but no other interactions.

Table 3.4. Results of three way analysis of variance for effect of participant sex (Sex), image breast size (Size) and image areola colouration (Colour) on sexual maturity ratings.

	Degrees of Freedom		F statistic
Sex	1,	99	0.070
Size †	2.54,	250.91	1149.20***
Colour †	1.89,	186.75	0.77
Sex × Size	3,	297	0.28
Sex × Colour	2,	198	1.81
Size × Colour†	4.8,	434.42	7.55***
Sex × Size × Colour†	4.16,	412.05	0.78

† = Greenhouse-Geisser correction applied to the degrees of freedom as the Mauchley's Test of Sphericity is significant for these tests.

*** = Significant at 0.001

Age

The analysis of variance for the age estimates showed that breast size is the only significant factor (Table 3.5). The sex of the participant ($p = 0.984$) and the areola colouration were not important in determining age estimates ($p = 0.079$). The only significant interaction was that between breast size and areola colouration.

Table 3.5. Results of three way analysis of variance of effect for participant sex (Sex), image breast size (Size) and image areola colouration (Colour) on age estimates

	Degrees of Freedom		F statistic
Sex	1,	99	0.000
Size †	2.44,	241.75	680.01***
Colour †	1.45,	143.56	2.82
Sex × Size†	2.33,	230.78	0.14
Sex × Colour†	1.49,	147.57	0.66
Size × Colour†	3.88,	383.61	3.40**
Sex × Size × Colour†	3.16,	312.57	0.52

† = Greenhouse-Geisser correction applied to the degrees of freedom as the Mauchley's Test of Sphericity is significant for these tests.

** = Significant at 0.01

*** = Significant at 0.001

Conclusions: Three way analyses of variance for attractiveness, health, nurturance, sexual maturity and age

Each image was rated on five traits – attractiveness, health, nurturance, sexual maturity and the age of the woman in the image. For each of these ratings, breast size was found to be a significant factor in ratings. For the attractiveness, health and nurturance ratings areola colour was important in determining ratings, but not for the other two ratings. For all five ratings, the interactions between breast size and areola colour were statistically significant.

Analysis of the effect of breast size

As the ratings for each image were significantly impacted by the size of the breasts, the ratings were compared by size within each colour group. Overall, the ratings increased with larger breast sizes. Closer analysis revealed how the breast size impacted the image ratings within each colour bracket. These analyses are shown in the graphs below.

Impact of breast size on Attractiveness ratings

The ratings of attractiveness generally increased with increasing breast size, with one exception (Figure 3.1). The light coloured areola group showed significant differences within the group ($F_{(3,796)} = 339.82, p < 0.001$). Scheffé tests showed that ratings for all four groups are significantly different to each other, except those for 80% and 120% sized breasts. The group with the original areola colouration have significant differences in ratings ($F_{(3,796)} = 363.16, p < 0.001$); Scheffé tests show this is driven by the images with 0% and 80% sized breasts being rated as significantly less attractive than the images with 100% and 120% size breasts as well as different to each other. The set of images with the darkest areola were all rated as significantly different to each other ($F_{(3,796)} = 413.72, p < 0.001$); in the Scheffé tests this was

expressed as the larger breasts being rated as systematically more attractive than the smaller.

Figure 3.1. The impact of breast size on ratings of attractiveness within each areola colour group. Error bars show Standard Error of the sample. Asterisks indicate significant p-values in Scheffé tests: *** <0.001. Illustrations overhead show the four breast sizes, in size order from left to right.

Impact of breast size on Health ratings

The health ratings generally peaked at the images with the intermediate breast size (Figure 3.2). In the group with the light coloured areola, the significance of the ANOVA ($F_{(3,796)} = 118.487$, $p < 0.001$) was driven by the image with the smallest breast being rated as significantly less healthy than the other three. The group of images with the original areola colour were also rated significantly different to each other ($F_{(3,796)} = 105.28$, $p < 0.001$); the image with 0% breast size was rated significantly less healthy than the other three images. The images with 80% and 120% sized breasts were also rated as different to each other. For the group with the darkest

areola, the two images with the smallest breasts (0% and 80%) were rated as significantly less healthy than the other two images (100% and 120%; $F_{(3,796)} = 145.32, p < 0.001$).

Figure 3.2. The impact of breast size on ratings of healthiness within each areola colour group. Error bars show Standard Error of the sample. Asterisks indicate significant p-values in Scheffé tests: ** < 0.01, *** < 0.001. Illustrations overhead show the four breast sizes, in size order from left to right.

Impact of breast size on Nurturance ratings

As the breast size increased, the ratings for nurturance increased (Figure 3.3). The three groups all show significant differences (light colouration group $F_{(3,796)} = 479.88$; original colouration group $F_{(3,796)} = 402.08$; dark colouration group $F_{(3,796)} = 415.34$, all p values < 0.001). Within all three areola colour groups the Scheffé comparisons indicated that all four breast sizes were rated as significantly different to each other, with the larger breasts being rated as progressively more nurturing.

Figure 3.3. The impact of breast size on ratings of nurturance within each colour group. Error bars show Standard Error of the sample. Within each colour group, all four breast sizes significantly different in Scheffé tests, $p = < 0.001$. Illustrations overhead show the four breast sizes, in size order from left to right.

Impact of breast size on Sexual Maturity ratings

The ratings of sexual maturity repeated the same pattern as nurturance (Figure 3.4).

As the breast size was increased, the images were given higher ratings (light colouration group $F_{(3,796)} = 591.64$; original colouration group $F_{(3,796)} = 453.94$; dark colouration group $F_{(3,796)} = 442.70$, all p values < 0.001). The Scheffé comparisons showed that within each colouration group the differences between all four breast sizes were statistically significant; larger breasts were given higher ratings.

Figure 3.4. The impact of breast size on ratings of sexual maturity within each colour group. Within each colour group, all four breast sizes are significantly different in Scheffé tests, $p < 0.001$. Illustrations overhead show the four breast sizes, in size order from left to right.

Impact of breast size on Age estimates

The age estimates for the twelve images increased with the breast size (Figure 3.5).

The group with the lightest colouration of the areola showed significant differences ($F_{(3,796)} = 376.61, p < 0.001$). The Scheffé tests indicated that this was driven by all four images being significantly different to each other, although the difference between the 80% and 100% image was smaller. This pattern was repeated for the image set with the original areola ($F_{(3,796)} = 358.53, p < 0.001$) and again in the dark areola group ($F_{(3,796)} = 209.13, p < 0.001$).

Figure 3.5. The impact of breast size on estimates of age within each colour group. Error bars show Standard Error of the sample. Asterisks indicate significant p-values in Scheffé tests: ** < 0.01, *** < 0.001. Illustrations overhead show the four breast sizes, in size order from left to right.

Conclusions: The impact of breast size on ratings of attractiveness, health, nurturance, sexual maturity and age

Judgements of attractiveness, health, nurturance, sexual maturity and age were all affected by the size of the breast. Generally, this was expressed by the larger breasts being given higher ratings. The effect of breast size was most pronounced on ratings of nurturance and sexual maturity; increasing the breast size resulted in higher ratings with clear differences between each breast size. Estimates of age were also strongly affected by breast size, although the two intermediate breast sizes were rated as closer in age. However, increasing the breast size from 100% (the original size) to 120% did not always result in higher perceived health or attractiveness ratings; in some cases the increased size even reduced the ratings.

Analysis of the effect of areola colour

The three-way analysis of variance indicated that areola pigmentation had a significant impact on ratings of attractiveness, health and nurturance. Accordingly, each dataset is compared within each breast size to test the independent impact of areola colour. The ratings change with areola colouration in different ways for each rating set.

The impact of areola colour on Attractiveness ratings

The impact of areola pigmentation on attractiveness ratings worked in different ways depending on the size of the breast (Figure 3.6); this was initially suggested by the significant interaction of these factors in the analysis of variance (Table 3.1). The areola colour had very little impact on attractiveness ratings in the set of images with the flat (0%) breasts ($F_{(2, 597)} = 0.901$, $p = 0.407$). The image sets with breast sizes of 80% and 100% showed an impact of areola colouration (80% $F_{(2, 597)} = 80.18$, $p < 0.001$; 100% $F_{(2, 597)} = 14.02$, $p < 0.001$). In both sets this was driven by the images being rated progressively less attractive as the areola was darkened. In the images

with 120% size breast, the pattern was reversed. The image with the lightest areola was the least attractive ($F_{(2, 597)} = 11.02$, $p < 0.001$) and there was no significant difference in ratings between the darker two images.

Figure 3.6. The impact of areola colouration on attractiveness ratings within each breast size group. Error bars show Standard Error of the sample. Significant p-values in Scheffé tests indicated: ** < 0.01, *** < 0.001. Illustrations overhead show the three areola colours, in order of light, original and dark from left to right.

The impact of areola colour on Health ratings

The impact of areola colouration on health ratings (Figure 3.7) is very similar its impact on attractiveness ratings. The areola colour again had no impact on ratings for the images with the smallest (0%) breasts ($F_{(2,597)} = 0.91$, $p = 0.913$). The images with a darker areola were rated as less healthy than the other two in the sets with 80% and 100% sized breasts (80% $F_{(2,597)} = 116.13$, $p < 0.001$; 100% $F_{(2,597)} = 5.13$, $p = 0.006$). The significance of these tests was driven by the differences between the lightest and

darkest images, and in the case of the 80% breasted data set, a smaller difference between the lightest and original images. There was no significant difference between the three areola colour tones in the largest, 120% sized dataset ($F_{(2,597)} = 1.66$, $p = 0.192$).

Figure 3.7. The impact of areola colouration on healthiness ratings within each breast size group. Error bars show Standard Error of the sample. Significant p-values in Scheffé tests indicated: ** < 0.01, *** < 0.001. Illustrations overhead show the three areola colours, in order of light, original and dark from left to right.

The impact of areola colour on Nurturance ratings

The impact of areola colour was significant in the three-way analysis of variance, but with a higher p-value than attractiveness and health (Table 3.3). The impression of areola colour being less important in nurturance ratings was repeated in the more detailed analysis (Figure 3.8). In the images with breasts sized at 0% and 100% there were no significant differences in nurturance ratings between the three areola colours at an alpha level of 0.01 (0%: $F_{(2,597)} = 0.792$, $p = 0.45$; 100%: $F_{(2,597)} = 3.62$, $p = 0.027$). The Scheffé tests showed no significant difference between the three areola

colours for these image sets. The small breasted (80%) image set showed a significant difference in nurturance ratings ($F_{(2, 597)} = 22.55, p < 0.001$); this was driven by the significant drop in nurturance in the darkest areola colouration. In the fourth set of images, with the largest (120%) sized breasts, the differences between the three areola colours tended towards significance (120%: $F_{(2, 597)} = 4.48, p = 0.012$). The image with the darkest areola was rated significantly more nurturing than the other two.

Figure 3.8. The impact of areola colouration on nurturance ratings within each breast size group. Error bars show Standard Error of the sample. Significant p-values in Scheffé tests indicated: ** < 0.01, *** < 0.001. Illustrations overhead show the three areola colours, in order of light, original and dark from left to right.

The impact of areola colour on Sexual Maturity ratings

The main effects analysis of sexual maturity ratings (Table 3.4) showed no significant effect of areola colour, which is echoed in the in-depth analysis (Figure 3.9). The image set with the smallest (0%) breasts showed no significant differences in ratings due to areola colour ($F_{(2, 597)} = 0.97, p = 0.38$). For the dataset with the small (80%) sized breasts, the differences tended towards significance ($F_{(2, 597)} = 3.44, p = 0.03$).

The images with the intermediate (100%) sized breast showed no significant difference between the three areola colourations ($F_{(2,597)} = 2.88$, $p = 0.057$), but there was a slight decrease in ratings with darkening areola. The averages from the images with the largest breast (120%) were significantly different from each other ($F_{(2, 597)} = 5.30$, $p = 0.005$). The Scheffé tests revealed that the darkest areola image was rated as significantly more sexually mature than the lightest areola.

Figure 3.9. The impact of areola colouration on sexual maturity ratings within each breast size group. Error bars show Standard Error of the sample. Significant p-values in Scheffé tests indicated: * < 0.05, ** < 0.01. Illustrations overhead show the three areola colours, in order of light, original and dark from left to right.

The impact of areola colour on Age Estimates

The independent analyses of the data separated by breast size (Figure 3.10) was only significant for the dataset with the largest breasts (120%). The large breasted image set ($F_{(2,597)} = 5.30$, $p = 0.005$) showed a significant Scheffé test result, with the darkest areola image being rated as older than either the lightest or original areola colour. The

other three image sets showed no significant differences between the three areola colours; 0% breast size $F_{(2,597)} = 0.39$, $p = 0.68$; 80% breast size $F_{(2,597)} = 0.13$, $p = 0.88$; 100% breast size $F_{(2,597)} = 0.642$, $p = 0.527$.

Figure 3.10. The impact of areola colouration on age estimates within each breast size group. Error bars show Standard Error of the sample. Significant p-values in Scheffé tests indicated: * < 0.05. Illustrations overhead show the three areola colours, in order of light, original and dark from left to right.

Conclusions: The impact of areola colour on ratings of attractiveness, health, nurturance, sexual maturity and age

Areola colouration was less important than breast size in perceptions of the five variables measured in this study. The colour of the areola did not impact the ratings at all in the smallest (0%) breast sized dataset. In the 80% and 100% breast sized sets, the darker areola tended to generate lower ratings, although this difference was not always statistically significant. In the set of images with largest breasts (120%) the darker areola resulted in higher ratings, especially for sexual maturity and perceived age.

Multivariate Correlations

The first correlation analysis examined the relationship between the raw data values for all twelve images. The analysis correlated each of the five ratings from each participant to the other four ratings for that same image. For each correlation between the raw data, the Pearson Correlation (r) was calculated and tested for a significant correlation (Table 3.6). All correlations were statistically significant ($p < 0.01$). This showed that the strongest correlation was between ratings of age and sexual maturity.

Table 3.6. Correlation matrix of the raw data for the five ratings. Above the diagonal shows the Pearson Correlation (r) of all ratings and significance tests ($df = 2398$). All correlations significant ($p < 0.01$). For comparison, the lowest correlation shown here is statistically significant at the 0.01 level (two tailed) even with much lower degrees of freedom of 40.

	Attractive	Healthy	Nurturing	Sexual Maturity	Age
Attractive	-	0.677	0.745	0.648	0.536
Health		-	0.607	0.507	0.405
Nurturing			-	0.738	0.648
Sexual Maturity				-	0.839
Age					-

Visual inspection of the distribution of the data suggested that these correlations may be at least partially caused by a weak correlation but very large sample size. In an attempt to correct for this, the five ratings were averaged across all 200 participants.

This resulted in five values for each of the twelve images; the Pearson Correlation (r)

for these values was correlated (Table 3.7). The strongest correlation was between sexual maturity and age.

Table 3.7. Correlations between the averages of ratings for each image. Below the diagonal shows the Pearson Correlation (r) of correlations between the average for each image and significance tests (df = 10). All correlations significant ($p < 0.01$). The critical value for the Pearson's r for 0.01 (two tailed) with df = 10 is 0.708.

	Attractive	Healthy	Nurturing	Sexual Maturity	Age
Attractive	-				
Health	0.982	-			
Nurturing	0.951	0.910	-		
Sexual Maturity	0.940	0.885	0.978	-	
Age	0.909	0.848	0.967	0.996	-

Overall Conclusions for Study 1:

The results of Study 1 indicated that the breast size and areola pigmentation of images had significant impacts on perceptions of attractiveness, health, nurturance, sexual maturity and age estimates, as measured by questionnaires. The effect of breast size was consistent and pronounced. The lowest ratings were always given to the images with the smallest (0%) breast. Increasing the breast size above this resulted in progressively higher ratings. In assessments of health and attractiveness, increasing the breast size beyond the original (100%) did not regularly result in higher ratings. In contrast, ratings of nurturance were highest for images with the largest breast size. The ratings of sexual maturity and estimates of age were also highest in the images with the largest (120%) sized breast.

Alterations to the areola colour resulted in more variable effects and interacted strongly with the breast size. An image with a darker areola was perceived as less attractive when paired with a small (80%) or original (100%) breast size, but more attractive when paired with a large (120%) breast. The images with darker areola were also perceived as less healthy when paired with a small or original breast size. The effect of the areola pigmentation was less important in determining ratings of nurturance, sexual maturity and estimates of age. These three ratings repeated the

pattern of a darker areola being rated higher and more mature when paired with a larger breast.

There was a strong correlation between each of the five ratings given to each image. When images were rated as more attractive, they were also rated as healthier, more nurturing, sexually mature and older. The closest correlation was between perceived sexual maturity and perceived age, regardless of whether the raw values or the averages for each image were used. These results will be discussed in Chapter Six.

Chapter 4 Results of Study 2: Breast Asymmetry

Attractiveness Ratings

Four way ANOVA Analysis for Attractiveness Ratings

Individual factor effects on attractiveness ratings

The four way analysis of variance indicated that the systematic modifications performed on the images to create breast asymmetry resulted in significant changes in attractiveness ratings (Table 4.1). Whether the modifications were on the right or left side of the images and how much the breasts had been modified had significant effects on the ratings. The type of modification, that is whether the position or volume was changed in one breast, was also strongly significant. The only major effect that was not significant was sex of the participant ($F_{(1,99)} = 1.00$, $p = 0.319$). Due to this, all further tests were performed with data from both sexes combined.

Table 4.1 Results of the four way analysis variance for attractiveness ratings of the images in the asymmetry study. The main effects are the sex of the participant (Sex), whether the modifications were made on the right or the left side of the image (Side), the extent of these modifications (Amt) and whether the modifications produced asymmetry in the position or volume of the breast (V/P).

	Degrees of Freedom		F statistic
Sex	1,	99	1.002
Side	1,	99	53.29***
Amt†	2.47,	244.8	555.97***
P/V	1,	99	564.12***
Sex × Side	1,	99	0.04
Sex × P/V	1,	99	3.85
Side × P/V	1,	99	0.19
Sex × Amt†	2.1,	207.62	1.70
Side × Amt†	2.78,	276.64	17.9***
Amt × P/V †	2.73,	270.42	28.34***
Sex × Side × Amt†	2.55,	252.30	3.46*
Sex × Side × P/V	1,	99	0.04
Sex × Amt × P/V †	2.68,	265.55	3.04*
Side × Amt × P/V †	2.79,	276.27	15.68***
Sex × Side × Amt × P/V	3,	297	0.13

† = Greenhouse-Geisser correction applied to the degrees of freedom as the Mauchley's Test of Sphericity is significant for these tests. Asterisks indicate significant p values, * < 0.05. *** < 0.001

Interaction Effects on Attractiveness ratings

There were significant interactions between both the extent of the asymmetry and the side of the body and the extent of asymmetry and the type of modifications. When sex

of the participant is combined with both of these interactions, the interaction was close to significance but did not reach the more conservative p value of 0.01. The only interaction effect to reach significance at the 0.001 level was between the amount of asymmetry, the side of the body and the type of asymmetry.

Impact on Attractiveness of Asymmetry in Breast Position

The first analysis examined the effect of the amount of asymmetry using only images which had been modified to be asymmetric in the position of one breast (Figure 4.1). This analysis separated the data by whether the modification was on the left or right side of the body and compared the four levels of modification. In this analysis, left and right refers to the side from the viewer's perspective. For both sides of the body, the comparisons between the four levels of modification was significant (right $F_{(3,796)} = 118.32$, $p < 0.001$ and left $F_{(3,796)} = 144.638$ $p < 0.001$). The Scheffé post hoc tests indicated that the most symmetrical images were the most attractive, and that there were significant differences between each level of asymmetry ($p < 0.001$). However, for the images modified on the right, the most asymmetrical image (4%) was rated as more attractive than the third most asymmetrical (3%).

T-tests compared the images that were modified on the left side of the body with the same modifications on the right side of the body. These tests were only significant for two of the pairs: those that had positional asymmetry of 2% ($T_{(398)} = 2.52$, $p = 0.012$) and 4% of the overall image length ($T_{(398)} = 6.9$, $p < 0.001$). The other mirror image sets were not significantly different from each other (for 1%: $T_{(398)} = 1.39$, $p = 0.09$, for 3%: $T_{(398)} = -1.17$, $p = 0.24$).

Figure 4.1. The average attractiveness ratings for images with the position of one breast modified. Left and right indicates side from viewer's perspective, percentage indicates percentage the breast's posterior margin was moved (as a percentage of the overall image length). Error bars show Standard Error of the sample. The two controls (Symmetrical and Original) are significantly different from all eight modified images; Right 2% vs Symmetrical control significance is $p = 0.018$. All other comparisons with controls are statistically significant with $p < 0.001$. Overhead bars show significant differences between mirror-image pairs, asterisks indicate significant p values, * < 0.05 , *** < 0.001 .

The ratings for the two controls were compared to the ratings of the systematically adjusted image using T-tests ($df = 398$). The results indicated that the original image was rated as significantly more attractive than the three most extreme modifications on both sides of the body (Figure 4.1). The symmetrical control was perceived as more attractive than all of the position modified images.

To assess the overall impact of increasing levels of asymmetry in the position of one breast, the ratings for left and right modified images for each level of asymmetry were combined. An analysis of variance was performed with these four new values and the two controls as the variables (Figure 4.2). This analysis showed a significant

difference between the six sets of variables ($F_{(5,1194)} = 191.369$, $p < 0.001$). The Scheffé tests indicated that except for the two most asymmetrical sets, all differences were significant. The symmetrical image was rated most attractive, followed by, in order, the 1% modified images, the original control, the 2% modified images and then 3% and 4% modified images (which were rated very similarly).

Figure 4.2. The average ratings of the two controls and the average ratings for each modification amount averaged between the left and right modified images. Error bars show Standard Error of the sample. 3% and 4% images are not rated as significantly different, $p = 0.998$. Original control significantly different to 2% average ($p = 0.006$). For all other comparisons, $p < 0.001$. Overhead illustrations show (from left to right) symmetrical control, original control, and an example of 1%, 2%, 3% and 4% position modified images.

Impact on Attractiveness of Asymmetry in Breast Volume

The impact of asymmetry in breast volume on ratings of attractiveness was also examined, and the analysis had the same structure as that for positional asymmetry (Figure 4.3). On both sides of the body, these analyses were significant (right: $F_{(3,796)}$

= 40.49, $p < 0.001$, left: $F_{(3,796)} = 111.55$ $p < 0.001$). The pattern of significant Scheffé test results was the same for both sides; the images with one breast enlarged to 102.5% and 105% volume were both significantly more rated as attractive than those images with one breast enlarged to 107.5% and 110%, ($p < 0.001$), but those pairs showed no significant difference.

T-tests were performed to compare the volume modified images to their mirror images (Figure 4.3). These tests indicated that the image modified on the right side of the image was significantly more attractive than that modified on the left for the two most asymmetrical pairs; 107.5% $T_{(398)} = 4.85$ and 110% $T_{(398)} = 4.49$. There was no significant difference between the 102.5% ($T_{(398)} = -1.12$, $p = 0.265$) and the 105% ($T_{(398)} = 0.45$, $p = 0.65$) volume modified images.

The ratings for the two controls were compared to the volume adjusted images using T-tests ($df = 398$). These tests indicated that the original image was rated as less attractive than the 102.5% and 105% volume images, and more attractive than the 110% volume images, on both sides of the body. The symmetrical control, on the other hand, was significantly more attractive than the three most extreme asymmetries on both sides.

Figure 4.3. The average attractiveness ratings for images with the volume of one breast modified. Left and right indicates side from viewer's perspective, percentage indicates the volume of the modified breast (compared to the original breast). Error bars show Standard Error of the sample. Symmetrical control was rated significantly more attractive than 105% ($p = 0.003$), 107.5% and 110% images for both left and right. Original control was rated significantly less attractive than 102.5%, and 105% images on the right and left, and more attractive than the 110% volume images on the left and right. Overhead bars show significant differences between mirror-image pairs. All non-stated p values < 0.001.

The overall impact of breast volume asymmetry regardless of side of the body was also analysed (Figure 4.4). This analysis showed that the two smaller adjustments (102.5% and 105%) were rated as significantly more attractive than the larger adjustments (107.5% and 110%) but within these pairs there was no significant difference. The symmetrical control was not rated significantly more attractive than the 102.5% volume modified average. The original image's attractiveness was rated between the 105% and 107.5% images.

Figure 4.4. The average ratings of the two controls and the average ratings for each modification amount averaged between the left and right modified images. Error bars show Standard Error of the sample. The symmetrical control was rated significantly more attractive than the original control and the 107.5% and 110% ($p < 0.001$) and the 105% ($p = 0.022$) averages. The original image was rated as less attractive than the average of the 102.5% and the 105% images ($p < 0.001$). The 102.5% and 105% sets were both more attractive than the 107.5% and 110% sets ($p < 0.001$). Overhead illustrations show (from left to right) symmetrical control, original control, an example of 102.5%, 105%, 107.5% and 110% volume modified images.

Other comparisons

To test how the types of modification affected the attractiveness ratings, the type of modification (position or volume) was included in the initial four way analysis of variance (Table 4.1). As the effect of this factor was significant, tests were performed between images which had been coded as the same amount of modification and the same side. These T-tests were all significant ($T_{(398)} = -3.34$ to -13.32 , $p \leq 0.002$). The two controls were also compared to each other. This showed that the symmetrical control was rated significantly more attractive than the original image ($T_{(398)} = 10.228$, $p < 0.001$).

Conclusions: Analysis of attractiveness ratings in asymmetry study

The attractiveness ratings were strongly influenced by the amount of asymmetry in the images. The symmetrical control, which had completely symmetrical breasts, was rated as more attractive than all other images except the image modified to have 1% asymmetry in position. As the images increased in asymmetry, the attractiveness ratings dropped. The exception to this was the image that was modified on the right with a 4% position modification, which was rated as more attractive than the 3% modification on that side. The original image was rated as less attractive than the 1% positional asymmetrical images and both of the 102.5% and 105% volume modifications.

Each of the modifications was displayed twice in the stimulus instrument – once on the right side of the image and once on the left. In the most extreme asymmetries, there was a significant effect of the side of the image; those images modified on the right from the viewer's perspective (on the model's left side) were rated as significantly more attractive than those modified on the left.

Health Ratings

Four way ANOVA Analysis of health ratings

Individual factor effects on Health ratings

The four way analysis of variance for the health ratings showed a very similar pattern of significance tests to the attractiveness data (Table 4.2). As there is no effect of sex of participant ($F_{(1,99)} = 0.161$, $p = 0.689$) the data for both sexes were combined for the rest of the analysis. The health ratings were significantly affected by which side of the body the modifications were made on and how severe these modifications were.

There is also a significant effect arising from whether the asymmetry is in the volume or position of the breast.

Table 4.2 Results of the four way analysis variance for health ratings of the images in the asymmetry study. The main effects are the sex of the participant (Sex), whether the modifications were made on the right or the left side of the image (Side), the extent of these modifications (Amt) and whether the modifications produced asymmetry in the position or volume of the breast (V/P).

	Degrees of Freedom		F statistic
Sex	1,	99	0.16
Side	1,	99	49.91***
Amt†	2.19,	216.52	288.74***
P/V	1,	99	195.85***
Sex × Side	1,	99	0.07
Sex × P/V	1,	99	0.07
Side × P/V	1,	99	1.04
Sex × Amt†	1.94,	181.83	2.15
Side × Amt†	2.7,	267.29	15.5***
Amt × P/V	3,	297	21.57***
Sex × Side × Amt†	2.75,	269.98	2.04
Sex × Side × P/V	1,	99	1.33
Sex × Amt × P/V †	2.64,	262.04	1.61
Side × Amt × P/V	3,	297	16.73***
Sex × Side × Amt × P/V †	2.79,	276.00	0.95

† = Greenhouse-Geisser correction applied to the degrees of freedom as the Mauchley's Test of Sphericity is significant for these tests. Asterisks indicate significant p values, *** < 0.001.

Interaction Effects on Health ratings

The extent of the asymmetry interacts with the side of the body and the type of modifications. The only significant three-way interaction was between the amount of asymmetry, the side of the body and the type of asymmetry.

Impact on Health Ratings of Asymmetry in Breast Position

The impact on health ratings of the amount of positional asymmetry in the breasts was analysed in same way as for the attractiveness data (Figure 4.5). For images modified on the right side of the body, the amount of asymmetry was strongly significant ($F_{(3,796)} = 65.186$ $p < 0.001$). The images with 1%, 2% and 3% positional asymmetry were rated progressively less healthy than each other (in Scheffé tests $p < 0.001$). However, the image with 4% asymmetry was rated as healthier than the 3% ($p < 0.001$). For the images modified on the left side of the body ($F_{(3,796)} = 76.675$ $p < 0.001$), progressive decreases in symmetry resulted in decreasing health ratings, with significant differences between each level ($p < 0.001$).

Figure 4.5. The average health ratings for images with the position of one breast modified. Left and right indicates side from viewers perspective, percentage indicates the distance the breast's posterior margin was moved (as a percentage of the overall image length). Error bars show Standard Error of the sample. Symmetrical control was rated significantly more attractive than all other images. Original image was rated significantly less attractive than 1% images on the left and right. The original image was rated significantly more attractive than the 2% on the left ($p = 0.038$) and 3% and 4% left and right images. Overhead bars show significant differences between mirror-image pairs (***) indicates $p < 0.001$). All other significant differences had p values < 0.001 .

The images that differed only in which side of the image was modified were compared with T-tests ($df = 398$). Only the 4% position modified images were significantly different in this analysis, with the image modified on the right rated as healthier ($T = 5.79$). The two control images were also compared to every other image using T-tests ($df = 398$). The symmetrical control was rated as healthier than the asymmetrical images ($T_{(398)}$ ranges from -3.62 to -19.2, $p < 0.001$). The original control was rated as significantly healthier than the right 3% and 4% positional asymmetric images, and the left 2%, 3% and 4% positional asymmetric images ($T_{(398)}$ ranges from -2.09 to -9.9).

The overall impact on health ratings of increasing asymmetry was analysed by combining the ratings for each extent of asymmetry on left and right. These were compared to the ratings of the two control images (Figure 4.6). This comparison indicated that the ratings are significantly different to each other ($F_{(5,1194)} = 95.364$, $p < 0.001$). The original image was not rated as significantly different to the 2% modifications ($p = 0.855$) and rated less healthy than the average for the left and right 1% position modified images. Increasing the asymmetry in the position of the posterior margin of the breast resulted in lower ratings, although the difference between the 3% and 4% averages was not significant ($p = 1$).

Figure 4.6. The average ratings of the two controls and the average ratings for each position modification averaged between the left and right modified images. Error bars show Standard Error of the sample. The 3% and 4% ratings were not significantly different to each other, nor were the original and 2% ratings. For all other comparisons, $p \leq 0.001$. Overhead illustrations show (from left to right) symmetrical control, original control, an example of 1%, 2%, 3% and 4% position modified images.

Impact on Health Ratings of Asymmetry in Breast Volume

The independent analyses of variance for the effect on health ratings of asymmetry in breast volume were significant on both sides (right: $F_{(3,796)} = 30.14$ $p < 0.001$, left: $F_{(3,796)} = 74.98$ $p < 0.001$). The two images with smaller asymmetries (102.5% and 105%) were both rated as significantly healthier than the two images with the largest asymmetries (107.5% and 110%, with $p < 0.001$).

Figure 4.7. The average health ratings for images with the volume of one breast modified. Left and right indicates side from viewer's perspective, percentage indicates the volume of the modified breast (compared to the original breast). Error bars show Standard Error of the sample. Symmetrical control was rated as significantly more healthy than right 102.5% ($p = 0.043$), 107.5% and 110% ($p < 0.001$). Symmetrical image was rated as more healthy than left 105% ($p = 0.004$) and 107.5% and 110% ($p < 0.001$). Original control is rated significantly less attractive than 102.5%, and 105% images on the right and left but more attractive than the 110% volume images on the left ($p = 0.009$) and right ($p = 0.006$). Overhead bars show significant differences between mirror-image pairs. *** indicates $p < 0.001$.

The images that were altered on the right side were rated as significantly healthier than the those altered on the left in the 107.5% ($T_{(398)} = 3.66$, $p < 0.001$) and 110% ($T_{(398)} = 3.6$, $p < 0.001$) cases. Both the symmetrical control and original image were

tested against the modified images with T-tests ($df = 398$); the symmetrical control was rated as healthier than all other images, although the difference was not always significant (Figure 4.7). The original image was rated as less healthy than the images with 102.5% or 105% volume in one breast, but more healthy than those with one breast enlarged to 107.5% or 110% volume (Figure 4.7).

To assess the impact of increasing asymmetry over both sides of the body, the ratings for the images that were modified identically, except for the side of the body were averaged and compared to each other and the controls (Figure 4.8). The increasing asymmetry did not result in significantly lower ratings except the step from 105% to 107.5% volume asymmetry. The symmetrical control was rated most healthy.

Other comparisons

To test how the types of modification affected the health ratings, the type of modification was included in the initial four way analysis of variance (Table 4.2). As this was significant, T-tests were performed between images which had been coded as the same amount of modification and the same side. These T-tests were almost all significant ($T_{(398)} = -4.1$ to -9.2 , $p < 0.001$). The 102.5% volume and 1% position modifications were not significantly different to each other on the right side ($T_{(398)} = -1.61$, $p < 0.108$) The two controls were also compared to each other, which showed the symmetrical control was rated as significantly healthier ($T_{(398)} = 8.62$, $p < 0.001$).

Figure 4.8. The average ratings of the two controls and the average ratings for each volume modification averaged between the left and right modified images. Error bars show Standard Error of the sample. The 102.5% and 105% volume modified images were both rated significantly higher than 110% and 107.5% ($p < 0.001$). The symmetrical control was rated higher than the original image and the 107.5% and 110% averages ($p < 0.001$). The original control was rated as significantly less healthy than the 102.% and 105% volume modifications ($p < 0.001$). Overhead illustrations show (from left to right) symmetrical control, original image and an example of 102.5%, 105%, 107.5% and 110% volume modified images.

Conclusions: Analysis of health ratings in asymmetry study

The health ratings were strongly influenced by the amount of asymmetry in the images. The symmetrical control was rated the most healthy overall. As the images increased in asymmetry, the health ratings dropped. Each of modifications were displayed twice in the stimulus instrument – once on the right side of the image and once on the left. In the most extreme asymmetries, there was a significant effect of the side of the body; the images modified on the right side of the images from the viewer's perspective were rated as significantly healthier than those modified on the left.

Multivariate correlation

There is a strong correlation between the attractiveness ratings and the health ratings.

When the two ratings for each image from each participant were correlated, the

Pearson product correlation between the health ratings and attractiveness ratings for each image was $r = 0.728$, which is a significant correlation ($df = 3598$, $p < 0.001$).

Visual inspection suggested that the scatter of this data was very wide and so the significant correlation may be partially driven by the very large sample size.

Accordingly, the average ratings for attractiveness for each image were correlated to the average ratings of health for that image. These showed a strong, statistically significant correlation (Pearson product $r = 0.996$, $df = 16$, $p < 0.001$) with increasing health ratings being associated with increasing attractiveness ratings.

Overall Conclusions for Study 2

The level of asymmetry in the breast strongly impacted the ratings of health and attractiveness an image received. This occurred whether the breasts were

asymmetrical in volume or asymmetrical in the position of their posterior margin.

Systematically increasing the level of asymmetry resulted in systematic reductions in ratings of health and asymmetry. However, the difference between the two most extreme levels of modification were less likely to have an impact on ratings, regardless of the type of modification.

There was no effect on the sex of the participant in this analysis and all data were pooled for the in-depth analysis. The symmetrical control was rated higher than the original image for both measures. Accordingly, these two images (completely symmetrical and original) had different patterns of significance when compared to the other images. The symmetrical control was given the highest ratings for attractiveness, while the original image was rated in the middle range of the other

sixteen images. The symmetrical control was also rated highest for health, and the original image again received intermediate ratings.

Modifications that were presented on both the left and right side of the body were not rated identically, and this effect was stronger in the images with the most extreme levels of modification. For attractiveness ratings, the image modified on the right side of the image (from the viewer's perspective) was given higher ratings in the 4% and 2% position modifications and in the two most extreme volume modifications (107.5% and 110%). This effect was also detected in the health ratings. The images with modifications on the right side were given higher ratings on the 4% position and 107.5% and 110% volume modifications.

The two ratings are strongly correlated to each other. If an image was given a high rating for attractiveness, it was also given a high rating for health. This connection was significant regardless of whether raw data or averages for each image were used. These results will be discussed in Chapter Six.

Chapter 5 Analysis of impact of images

Introduction

A number of studies have attempted to assess the importance of breast size in perceptions of personal attributes, attractiveness, and suitability as a partner. These studies typically use individually developed sets of images which systematically vary in several factors thought to be related to human attractiveness. Study participants are asked to rate the stimuli, and these ratings are thought to express some aspect of evolutionary fitness and mate selection processes.

Unlike studies on other species, it is usually not possible to make direct experimental modifications of human sexually selected features for the purpose of assessing their impact on fitness. Several analyses have used unaltered images of women to investigate correlations between breast size (usually uncorrected for body mass index) to attractiveness (Thornhill and Grammer 1999; Rilling et al. 2009). These have found that large breast sizes are negatively correlated with attractiveness, albeit weakly - Thornhill and Grammar (1999) found an r of -0.215, while Rilling found r 's of -0.12 to -0.50 depending on the angle of viewing (2009). This negative correlation is probably related to the fact that the women with high body mass indices (weight scaled for height) also had large breasts (Thornhill and Grammer 1999).

The wide variety of stimuli employed in these investigations have produced mixed results. Several publications reported that images with smaller breasts had more appeal to both sexes (Kleinke and Staneski 1980), or were rated as more attractive (Furnham and Swami 2007). Others have reported that larger breasts resulted in images receiving higher ratings for attractiveness (Scodel 1957; Gitter et al. 1983; Singh and Young 1995; Swami et al. 2009). When women had their breast size

modified with bra inserts, it resulted in more approaches from men in real social situations (Gueguen 2007b) and offers of help from men, but not women (Gueguen 2007a) when the breasts were largest. Yet another exercise using a video stimuli showed that an intermediate breast size (produced by bra inserts) resulted in the most favourable ratings (Tantleff-Dunn 2002). Studies using static images have also reported that the figure with the intermediate sized breast was preferred (Wiggins et al. 1968; Beck et al. 1976; Thompson and Tantleff 1992; Krantz et al. 1997; Grundl et al. 2009). Another set of reports indicated no significant effect of breast size on men's ratings of attractiveness (Horvath 1981; Dixon et al. 2009) or that breast size interacted in complex ways with other factors (Furnham et al. 1998; Furnham et al. 2006).

Many of these analyses were performed using two dimensional images of women. The line drawings originally created by Singh (1993) have been modified for use in a variety of different tests. The base line drawing of a female figure wearing a Western one-piece swimsuit covering the breasts and genitalia is retained in these modifications. The image is drawn as with one leg slightly bent and placed in front of the other (see Figure 5.3 for an example). Other line drawings have also been developed, for instance those in Thompson and Tantleff's (1992) study which are similarly clothed, and those in Furnham et al. (1990) which represent nude bodies.

Another set of images that has been used in several studies was developed by Wiggins and colleagues (1968). These black, detail-less silhouette images (See Figure 5.7 for an example) were also used by Beck et al. (1976) and Furnham and Swami (2007). A different set of silhouette images was developed by Marlowe et al. (2005) and these images have been modified and used by Swami and colleagues (2009 see Figure 5.4).

More recently, photographic manipulation software such as Photoshop has become easily available and this makes systematic modifications of photographs for use as stimuli possible (for examples, see Dixon et al. 2009; Grundl et al. 2009).

However, two dimensional images are problematic because actual judgements are made on three-dimensional people. Most authors acknowledge this fact, and some have attempted to introduce the third dimension into their research. For example, some studies use three dimensional models instead of static images. Such stimuli can be either videos of an individual (Smith et al. 2007) or a 3D computer model of them (Fan et al. 2004). A simpler solution that has been used by Gitter (1983) is to use two images, showing the body from two different angles.

Regardless of what stimuli are used, however, there is a tendency to assume that ratings in such studies relate directly to the attractiveness of real people. For example, Furnham and Swami (2007) concluded in their discussion that “overall, the evidence suggests that there are no stable preferences for female breast size”. In Swami et al. (2009) this idea is repeated: so that his research added to the “growing body of evidence indicating cross-cultural differences in what is considered an attractive female body”.

Swami briefly discussed the idea that some images may have “poor ecological validity”; this was based on the observation that most mean ratings on one study were “between 4.5 and 6.0 on a nine-point scale” (Swami et al. 2009). However, studies using images of real people do not seem to fare much better. Rilling and colleagues (2009) used photographs and 3D models of 43 real women and the average attractiveness rating was 4.9/10. Only two models received an average rating higher than 6/10 (Rilling et al. 2009). Using altered photographs in my own research has

provided similar results. In my study on breast sizes and areola pigmentation, the highest average rating was 3.55/5 (Chapter 3). The highest rating from the asymmetry study was only 3.9/5 (Chapter 4).

Rather than assessing the relative attractiveness of real traits in real people, many of these analyses may in fact only be assessing the impact of these changes on perceptions of the images. At this stage, such studies appear to be one of the cheaper and more practical ways of assessing attractiveness of various features. However, the fact that these studies use ratings of images and not true measures of fitness, (or even well established proxies of fitness) of real individuals is often glossed over.

In comparing studies, it has always been assumed that all sets of images, while being different, were comparable in how well they represented morphological traits. In no previous study have different types of images been shown to one study population, so it is entirely unclear that this is the case. This study examines this question by showing different types of images to one group of participants who rate all images for attractiveness and health.

Methodology

Stimulus instrument

The stimulus instrument was comprised of images taken from multiple sources.

Publications which assessed the impact of breast size on attractiveness were collated, including those which assessed the impact of several factors. Studies were considered for inclusion if the stimulus images had been published and the relative attractiveness of the images could be established. This excluded all research based on correlations between real breast sizes and attractiveness, such as Rilling et al. (2009). It also

excluded work based on videos (for example Tantleff-Dunn 2002) or real women using bra inserts (such as Gueguen 2007a).

For each study, the image which garnered the highest possible average rating was extracted from the published study and replicated in the new stimulus instrument. In the case of Wiggins (1968) the most attractive image was not included in the paper, however the second most attractive study was available and was included. The image taken from Study 1, this thesis was the 120%, dark areola image. This image, while not rated as the most attractive overall, gained the highest combined rating from attractiveness, health, and nurturing scores. Where studies reused the exact same set of images, the oldest publication which fulfilled the criteria was included and the others discounted. The selected images were collated into a Powerpoint presentation and the order randomised (Table 5.1). The eleven images used have been replicated in Figures 5.1-5.11.

Table 5.1. The origin and order of images used in the stimulus instrument for this study.

Origin of the image	Order in presentation	Figure	Type of image
Dixson et al. 2009	1	5.1	Photograph
Grundl et al. 2009	2	5.2	Photograph
Singh 1995 study 2	3	5.3	Line Drawing
Swami and Hull 2009	4	5.4	Silhouette
Thompson and Tantleff 1992	5	5.5	Line Drawing
Study 1, this thesis	6	5.6	Photograph
Wiggins et al. 1968	7	5.7	Silhouette
Furnham et al. 2006	8	5.8	Line Drawing
Gitter et al. 1983	9	5.9	Line Drawing
Singh 1995 study 1	10	5.10	Line Drawing
Furnham et al. 1990	11	5.11	Line Drawing

Study participants

Participants for this study were recruited opportunistically, with the aim of recruiting from a wide range of ages, socio-economic levels, ethnicities and educational levels.

Figure 5.1. First image in the stimulus instrument. From Dixon et al. 2009.

Figure 5.2. Second image in stimulus instrument. From Grundl et al. 2009

Figure 5.3. Third image in the stimulus instrument. From Singh 1995, study 2.

Figure 5.4. Fourth image in stimulus instrument. From Swami and Hull 2009.

Figure 5.5. Fifth image in the stimulus instrument. From Thompson and Tantleff 1992.

Figure 5.6. Sixth image in the stimulus instrument. From Study 1, this thesis.

Figure 5.7. Seventh image in the stimulus instrument. From Wiggins et al. 1968.

Figure 5.8. Eighth image in stimulus instrument. From Furnham et al. 2006.

Figure 5.9. Ninth image in stimulus instrument. From Gitter 1983.

Figure 5.10. Tenth image in stimulus instrument. From Singh 1995, study 1.

Figure 5.11. Eleventh image in stimulus instrument. From Furnham et al. 1990.

As this was intended to be a pilot study, only a small number of participants were recruited (Table 5.2). All thirty-seven participants were given the same briefing, informing them that they would be viewing nude female images. They were told that they could excuse themselves from the study at any point, how the data would be processed, and that their answers would remain anonymous. They were not told the specific questions being assessed until after data collection.

Each participant was asked to fill out a brief demographic questionnaire. This asked their sex, age, ethnic identity (Pakeha/European, Maori, Other), NZ citizenship status and marital status (Single, De Facto, Married, Divorced/Separated). This was filled out during briefing. A copy of the questionnaire sheet is in the Appendices (A1).

Table 5.2 Demographic data for participants in image study.

Demographic information of participants		
	Males	Females
<i>N</i>	20	17
<i>Age</i>		
Mean	23.6 ± 3.4	21 ± 3.04
Minimum-Maximum	18 – 30	18 – 29
<i>Ethnicity (n)</i>		
Pakeha/European	17	16
Maori	1	0
Other	2	1
<i>NZ Citizen (n)</i>		
Yes	17	15
No	3	2
<i>Marital Status (n)</i>		
Single	15	15
De Facto	3	1
Married	1	1
Divorced/Separated	1	0

Rating Scales

For each image, the participants were asked to give a rating on a five-point Likert Scale for attractiveness and health. These two rating scales were used as they are commonly

used as proxies for fitness in other studies, and easily understood by participants. The scales are shown below:

Attractiveness ratings:

- 1 = Unattractive
- 2 = Slightly attractive
- 3 = Average
- 4 = Very attractive
- 5 = Extremely attractive

Health ratings:

- 1 = Unhealthy
- 2 = Slightly healthy
- 3 = Healthy
- 4 = Very healthy
- 5 = Extremely healthy

Stimulus presentation

The Likert scales were explained and participants were asked not to use fractions or ranges in their answers, and asked not to confer with each other until after the study was complete. Participants viewed the stimulus images on a laptop screen, either singly or in small groups. Each image was screened for twenty seconds. At the end of the study, the participants were debriefed.

Data analysis

All data were entered into a spreadsheet, and SPSS (version 17.0) was used for the statistical analysis. No sheets had to be discarded due to being incompletely or incorrectly filled out. The first analysis compared the ratings for the eleven images in a one-way analysis of variance. Independent analyses were run for attractiveness and health data. This analysis did not take into account the image type (photographic, silhouette or line drawing). A second set of analyses compared the ratings for each image within each type and a third analysis compared the overall average for each image type.

Results

Impact of image type on attractiveness ratings

The analysis of variance across all eleven images revealed significant differences in ratings ($F_{(10,396)} = 10.274, p < 0.001$). The highest ratings were given to the three photographic images. The ratings given to silhouette and line drawing ratings were

similar, ranging from 2.30 to 2.78 (Figure 5.12). To test if the groups are rated significantly differently to each other, T-tests ($df = 72$) comparisons were made between the lowest and highest rating images between each image type. These showed that the lowest rated photograph was rated as significantly more attractive than the most attractive silhouette or line drawing. However, there was no significant difference between the highest and lowest ratings for the silhouettes or line drawings (Figure 5.12).

Figure 5.12. Mean attractiveness ratings of eleven images. Error bars show Standard Error of the sample. Overhead bars indicate significant ratings between highest and lowest rated images in each set (divided by type of image). Swami 2009 and Wiggins 1968 were not rated significantly different to Thompson 1992 or Gitter 1983. Image from Study 1 was rated significantly higher than highest rated silhouette and line drawings ($p \leq 0.001$). Asterisks indicate significant p values, * < 0.05, ** < 0.01, *** < 0.001.

The images were separated by type and an analysis of variance was performed for each type. The photographic images were not rated as significantly different to each other ($F_{(2,108)} = 0.984$, $p = 0.377$). The two silhouettes were approaching a significant difference ($T_{(72)} = 2.153$, $p = 0.035$). The six line drawings showed no significant differences in ratings of attractiveness ($F_{(5,216)} = 1.112$, $p = 0.335$). The average rating

for each group was also calculated and compared with an analysis of variance. This indicated that there was a significant difference ($F_{(2,108)} = 27.57, p < 0.001$) between the three types of images, which was driven by the average for the photographic images being significantly higher than the average ratings for the other two image sets (Figure 5.13).

Figure 5.13. The average attractiveness ratings from each participant averaged by the type of image. The average attractiveness ratings for the photographic images was significantly higher than either the line drawing or the silhouette images ($p < 0.001$). There was no significant difference between the second and third groups.

Impact of image type on health ratings

The single analysis of variance across all images indicated significant differences ($F_{(10,396)} = 9.798, p < 0.001$). Once again, the photographic images had the highest ratings (3.54 to 3.7). The silhouette images and the line drawing images overlapped in health ratings; ratings ranged from 2.49 to 3.46. To assess how the groups overlapped, pairs of images between each group were compared using T-tests ($df = 72$). These showed that the lowest rated photograph was rated as significantly healthier than the four least healthy line drawings, and the least healthy silhouette (Figure 5.14).

Figure 5.14. Mean health ratings of eleven images. Error bars show Standard error of the sample. Overhead bars indicate significant differences in health ratings between images. Asterisks indicate significant p values, * < 0.05, *** < 0.001.

The images were divided by type and an independent analysis of variance was run on each type. The photographic images were not rated as significantly different to each other ($F_{(2,108)} = 0.413$, $p = 0.663$). The two silhouettes were rated as significantly different to each other ($T_{(72)} = 2.153$, $p = 0.001$). Unlike in the attractiveness ratings, the six line drawings showed significant differences ($F_{(5,216)} = 5.900$, $p < 0.001$). However, only one pair of images were significantly different at the 0.01 level (Thompson 1992 and Gitter 1983), and a second pair at the 0.05 level (Thompson 1992 and Singh 1995, study 1) according to the Scheffé comparisons performed on the six line drawing images.

The health ratings were also averaged across each image type and compared using an ANOVA design (Figure 5.15). This indicated a significant difference ($F_{(2,108)} = 17.968$, $p < 0.001$). Closer inspection showed that this was driven by the average rating for the photographic images being significantly higher than those for the silhouette or line drawing images.

Figure 5.15. The average health ratings from each participant averaged by the type of image. The average attractiveness ratings for the photographic images was significantly higher than either the line drawing or the silhouette images ($p < 0.001$). There was no significant difference between the second and third groups.

Discussion

These results showed that the type of image can be very important in ratings of attractiveness and health, perhaps more so than other qualities of the image. Thus, the morphological changes being made to breasts in attractiveness studies may be secondary as a determinate of attractiveness. The photographic images were rated as more attractive than the two types of drawn image, both individually and when the

averages were computed. The attractiveness ratings for line drawing and silhouette image types were not different to each other either in individual ratings or using the average for each type. For health ratings, the pattern was slightly different. The averages for each type of image were compared, and the photographic images were rated as healthier than the line drawings or silhouettes. However, the photographic image that was rated as most healthy (from Study 1, this thesis) was not rated as significantly more healthy than the most healthy images for the silhouette group (Swami 2009) or the line drawing group (Thompson 1992).

It is clear from these data that the type of image is important in the ratings given in attractiveness studies. As the images selected for this study were given the high ratings in the various published accounts, it appears that variations in ratings in this analysis is due, in part, to the technique used to generate the various images. The image taken from Wiggins et al. (1968) was the second most attractive one their image-set (the most attractive was not published), and any difference in ratings between this image and others could be informative. This image did receive relatively low ratings for health and attractiveness, and it was rated as significantly different from the highest rating photographic images but it was consistently given similar ratings to other drawn images.

Swami et al. (2009) discussed the idea that drawings have low ecological validity, which is why they are given such low ratings in attractiveness studies. However, this does not appear to be the case in this data set. The photographs theoretically should have higher ecological validity, being more detailed, having proper skin tone and realistic proportions. While this did result in higher ratings of attractiveness and health for such images, it did not result in mean ratings higher than 4/5.

The present study thus highlights some of the problems in comparing reports that use disparate images as stimuli. Unless the effect of the type of images used in each study is clearly known, comparisons between them are not comparing “like with like”. While the original analyses from which source images were taken have reported no order effects (for example Cohen and Tannenbaum 2001), images used in previous work have been relatively homogenous. In this study where the images are much less homogenous, the order of the images may have been an important factor. While the images were randomly assigned their viewing order, the first image was a photograph and the line drawings fell towards the later part of the presentation. For a full-scale replication of this analysis, controlling for order effects should be incorporated into the design.

By showing a wide variety of images to one study population, I was able to assess how important the type of image is in attractiveness studies. The results indicated that the technique used to generate the images (for example photographs vs drawings) may have a greater effect upon attractiveness than judgements based on the morphology of the images (for example changes in breast sizes). Future research should take this into account when developing images for use in research on human morphology, mate choice and sexual selection.

Chapter 6 Discussion

The impact of breast size and areola colour

The impact of Areola Colouration

The first section of this thesis investigated the impact of breast size and the colour of the areola on perceptions of five measures. A detailed analysis revealed complex interactions between the two factors. Changing the areola colour on images of a flat chested young woman had no effect on ratings of attractiveness, health, nurturance, sexual maturity or estimates of her age. Performing the same colour changes on other sets of images had significant, but opposite, effects depending on whether the breasts are small or large. On the two image sets with smaller breasts, adjusting the areola from lighter to darker resulted in lower averages for all five ratings, although the statistical tests showed these differences were not always significant. The reverse pattern was true on the images with the largest breasts – darker areolae lead to increased ratings. In the initial analysis of variance, the impact of areola colour alone was not significant for the sexual maturity ratings and age estimates; in the more detailed analyses, these ratings were not as sensitive to areola colour as the other three.

Very little research has been done on the effect of areola colouration on perceptions of attractiveness. One study that used similar photo-manipulation techniques to this thesis investigated the impact of the colouration of areola in several Pacific Island populations and found it to be a significant factor in a forced choice experiment (Dixon et al. under review, pers comm). New Zealand men tended to prefer the medium coloured areola, while Papua New Guinean and Samoan men tended to prefer the dark areola (Dixon et al. pers comm). Dixon's research replicates the finding of this thesis that areola colour impacts on perceptions of attractiveness, and also that areola pigmentation interacts with other traits. Dixon's analysis used only one breast size, and the preference for the

medium coloured areola shown by the New Zealand sample may be an “average” of the two opposing effects of areola colour shown in this thesis.

The impact of Breast Size

Breast size was an important factor in all five of ratings for the images in the first study in this thesis. The attractiveness ratings for the light coloured areola and original coloured areola image sets were highest for the medium breast size (100% breast). This pattern was repeated for the health data. A different pattern was shown in the nurturance and sexual maturity ratings and age estimates; progressive increases in size resulted in progressively higher ratings.

Breast size has been studied extensively in many contexts and the results have been varied and contradictory, so it is unclear how to compare this analysis with the wealth of previous data. The analysis performed on different images showed that the type of image is extremely important in assessments of attractiveness, even when the images are theoretically very similar (Chapter Five, and discussed briefly below). Therefore, comparisons with the extant literature are restricted to those using photograph quality images. Dixon and colleagues (2009) used an eye-tracker to examine the relative importance of breast size and waist-to-hip ratio on how men looked at women’s bodies and how attractive they rated an image. When the breasts were small or large, they attracted relatively more attention than the rest of the body (compared to when the breasts were the original size) (Dixon et al. 2009). This eyetracking experiment used a very similar technique to modify the breast sizes – digitally altering only the breast, enlarging it to 120% or reducing to 80% of the original size (Dixon et al. 2009). It is interesting to note that while the breast size did not have a statistically significant effect on attractiveness ratings, the original breast was rated more highly (Dixon et al. 2009).

Grundl (2009) used a different methodology in an online experiment assessing the impact on attractiveness of several features, including breast size. Visitors to the website (www.beautycheck.de/english/experimente) were free to alter five traits (breast size, weight, hip width, waist width, and leg length) to view all two hundred and forty three possible options and choose the one they found most attractive (Grundl et al. 2009). The five most chosen images all included the intermediate breast size, which was the original breast size for that image (Grundl et al. 2009). These two studies using photograph quality images echoed the findings of the first section of this thesis – that the intermediate (and in these instances, the original) sized breast were rated as most attractive.

Changes during development

The images in the first section on breast size and areola colour were specifically modelled to mimic some of the changes that occur in breasts during puberty and development. Pre-pubescent girls have flat, androgynous chests until breast development begins (usually somewhere between 8 and 12 years of age); breast growth is usually complete by 18 years of age (Tanner 1978). In pregnancy and lactation the breast temporarily grows even larger. The areola colouration also models the darkening that occurs in development and pregnancy (Garn et al. 1956). It does not appear that participants in this study were interpreting the morphological changes in this manner. Sexual maturity and age ratings were extremely sensitive and positively correlated to breast sizes. However, the areola colouration did not have the same effect on these ratings; despite the biological reality, darkening areola colouration resulted in lower age and sexual maturity ratings for some breast sizes.

The participants in this study were sensitive to cues in the breast morphology that may hint at fertility levels. The attractiveness of the breast was highest in images that

indicate that puberty had occurred, but not the most extreme values, which may have indicated pregnancy. This result is consistent with much of the sexual selection theory discussed earlier.

Other traits the breast morphology may be reflecting

Nurturance ratings were assessed to see whether participants interpreted morphological changes as how able a woman is to care for infants, as several theories have been suggested that link female investment and breast size (Caro 1987). The data collected indicated that breast size is extremely important in nurturance ratings. Increasing the breast size resulted in increased nurturance ratings across all areola colourations.

However, changing the areola colouration gave conflicting results for nurturance ratings across different breast sizes. Considering those theories that interpret the breasts as maternal investment indicators and signals of good nutrition (as suggested by Gallup 1982), it makes sense that the areola colouration would be secondary to breast size.

After all, a woman who had successfully gone through puberty but then lost large amounts of weight would presumably have the darker areola, but smaller breasts. In a situation of variable food resources, the breast size would be a more useful signal.

Another interpretation is that the participants (mostly young adults from a Western society) have had relatively little chance to see a variety of bare breasts in different life-stages and therefore not learned much about areola colouration.

The images with the largest breast sizes were rated as less healthy than those with the medium (100%) size for the lightest and original coloured datasets. This may be reflecting the “common knowledge” that women with very large breasts often suffer back and neck pain. (The fact that women often do experience this pain (Chadbourne et al. 2001) is secondary in this analysis to the participants knowledge of the phenomena.) In the image set with the darkest areolae, the largest breast size was given the highest

health ratings. This was due to the dark areola, 100% image being rated unusually low for the breast size, rather than the 120% sized image being rated particularly high.

Areola colour was an important factor in determining health ratings according to the three way analysis of variance. However, its effect was restricted to the images with 80% sized and 100% sized breasts, where the darker areola resulted in lower health ratings. The pigmentation of areolae is oestrogen dependent (Levin 2006), and greater levels of oestrogen may be linked to compromised immuno-competence (Manning et al. 1997).

The results of the current study confirm that breasts *per se* are attractive. The set of images with a flat chest were given the lowest ratings in all five measures (except in healthiness, where the 80% breast size, dark areola image was given equally low ratings). Arieli (2004) has previously suggested that breasts, as a marker of femininity in and of themselves, may be attractive and that their sexual dimorphism may have been all that was required to make them a sexual attractant.

The impact of asymmetry

The second major study in this thesis showed that increasing levels of asymmetry resulted in images being rated lower for health and attractiveness. The image with symmetrical breasts was rated as more attractive and healthy than the original image, which was noticeably asymmetrical. The images that had been altered to be systematically less symmetrical were given lower ratings, roughly in order of their level of symmetry. The original control was often given lower ratings than the images with smaller levels of asymmetry. However, it is also less symmetrical than some of these images.

This study is a replication and extension of previous work on the impact of symmetry on attractiveness, and shows a much stronger effect of asymmetry than has previously been reported. Tovée (2000) used a forced choice experiment design, asking participants to choose between the original images of women and images symmetrised by combining the original and left-right mirror images. The symmetrised version was chosen 55.5% of the time (Tovée et al. 2000). The same images were not given significantly different attractiveness ratings when judged independently (Tovée et al. 2000). Another study dealing only with facial asymmetry suggested that sensitivity to symmetry may be dependent on the environment. Members of the Hazda, an African hunter-gatherer group, showed a higher sensitivity to symmetry (symmetrical image was chosen 61.9% of the time) than British participants (who chose the symmetrical version 56.5% of the time) in a forced choice experiment (Little et al. 2007).

Previous work on breast asymmetry has been limited. Singh (1995) used a set of line drawings to assess the impact of waist-to-hip ratio and breast asymmetry. His data showed that breast asymmetry significantly reduced attractiveness ratings (Singh 1995). However, the images used in this study are problematic. They are not front-posed, making assessment of symmetry difficult and, as a result, the “no asymmetry” image looks almost as asymmetrical as the “low asymmetry” image. Weeden and Sabini (2005) argue fluctuating asymmetry is usually very subtle, and that such line drawings are potentially inappropriate to convey these subtleties.

Another study used unaltered photographs of women and correlated their fluctuating asymmetry and attractiveness ratings (Schaefer et al. 2006). This showed a significant correlation between increasing fluctuating asymmetry and lower attractiveness ratings

for images of the front of the body but not the back (Schaefer et al. 2006). This suggests that breast asymmetry may be responsible for at least part of the correlation.

Fluctuating asymmetry and sexual selection

This thesis examined the effect of fluctuating asymmetry; random variations from bilateral symmetry that are thought to result from environmental stressors and poor genetic health (Møller et al. 1995). Humans are bilaterally symmetrical, and both sides of the body are theoretically determined by identical genetic mechanisms. Any deviation from symmetry is therefore evidence of poor implementation of the “genetic blueprint” and lower relative fitness (Møller et al. 1995). This is distinguished from directional asymmetry, where one side of an organism is habitually larger than the other.

There is good evidence that fluctuating asymmetry predicts fertility and fitness in humans. Jasieńska and colleagues (2006) found that women with relatively more symmetrical fourth fingers have higher levels of oestradiol, which is indicative of a greater likelihood of conception (Lipson and Ellison 1996). A study of women in two populations, Spain and New Mexico, revealed that those with higher levels of asymmetry had fewer children (corrected for age, Møller et al. 1995). This finding was repeated in Britain (Manning et al. 1997) where asymmetrical women had their first child later in life. Asymmetry in breasts has also been linked to a higher prevalence of breast cancer (Scutt et al. 1997).

Møller argues that fluctuating asymmetry is often higher in sexually selected traits due to directional selection resulting in minor breakdowns of regulatory mechanisms (Møller et al. 1995). Human breasts have higher levels of fluctuating asymmetry than many other traits. In humans, for instance, levels of relative breast asymmetry have been

reported to be 5% (Møller et al. 1995), 7% (Hussain et al. 1999) and 3.6% (Brown et al. 2008). Non-sexually selected traits in humans are generally reported to have relative fluctuating asymmetry levels of 1 or 2% (Auerbach and Ruff 2006; Brown et al. 2008). Several researchers have suggested that preferences for sexually dimorphic traits are linked to symmetry. Little and colleagues (2008) found that males and females were more sensitive to asymmetry in opposite sex faces than same-sex faces, but that overall symmetry was preferred by a small but significant margin. There was also a correlation between preference for symmetry and preference for sexually dimorphic features in opposite sex faces (Little et al. 2008). The stronger preference for symmetry in opposite-sex individuals shown in Little's (2008) work was not shown in the breast studies in this thesis; males and females showed no difference in the ratings of asymmetric breasts. This could be partially due to the different style of questionnaire; forced choice questions such as those used by Little (2008) address the attractiveness of symmetry vs asymmetry, whereas the work in this thesis assessed the impact of systematic increases in symmetry.

If fluctuating asymmetry is an honest signal of fitness, as some of these studies suggest (for example Møller 1999) there could be a clear benefit to individuals who are more sensitive to it. Choosing high-quality mates could result in greater reproductive success, and so sensitivity for signals of quality could have been selected for in the population (Møller et al. 1995).

Modifications on the left side or the right side

The asymmetry study reported here assessed the impact on ratings when the asymmetry was modelled on either the left or right side of the body. Each image apart from the controls was left-right flipped and both images were included in the stimulus instrument. When the level of asymmetry was high, the images that had been modified

on the model's left side (which was viewed as the right from the viewer's perspective) were given higher ratings of attractiveness and health. This effect has not been reported previously in studies of asymmetry, partially because of the differing methodologies of the older studies. Neither correlations between ratings of real people (for example Thornhill and Grammer 1999 using images of women's bodies) nor original versus symmetrised study designs (for example Tovée et al. 2000 using images of whole bodies; Little et al. 2007 looking at asymmetry in faces) are capable of detecting this kind of preference. Previous work published by Singh (1995) used an image set that changed the breast sizes on both the left and right, however each individual participant only viewed changes on one side of the body.

However, a similar impact of laterality has been detected in some other kinds of research. One early exploration of the effect showed that, when asked to mark the midpoint on a block of wood by touch, study subjects systematically neglected the right side, resulting in a left bias in their estimates. This was termed "pseudoneglect" (Bowers and Heilman 1980) and has been reported in several other test systems (for example the relative size of geometric shapes presented in the left or right visual field Charles et al. 2007). In exploring pseudoneglect phenomena in a visual line bisection task, Brodie and Dunn (2005) found that left and right handed subjects differed in their expression of pseudoneglect. Unfortunately, the symmetry analysis in this thesis did not collect handedness information from participants and so a closer analysis of this question is not possible.

The images used in this study were developed so that one breast was "normal" – unchanged from its original morphology – and the other was modified. This could explain a pseudoneglect-like phenomenon. In the images modified on the right side of

the images (from the viewer's perspective) the "normal" breast was in the left visual field, where it may have been given more attention than the modified breast. This could have resulted in higher ratings, compared to images designed so that the altered breast was in the more attended left visual field. It would be an interesting extension to see if images that have both breasts modified in different ways or to different extents still produce a bias towards images with the modification in the right visual field.

Another possible explanation of the current results is based on the principle that humans are not fully bilaterally symmetrical. Aside from internal organs being orientated to one side or the other, skeletal structure shows a slight directional asymmetry with the right upper body bones tending towards being longer and larger (Auerbach and Ruff 2006; Kujanová et al. 2008) except for the clavicle, which tends to be longer on the left (Auerbach and Raxter 2008). In the current context, the clavicle is a more relevant asymmetry than limb bones, as it is near the breast and its length is reflective of the width of the torso.

The results showed that asymmetry on the model's left side (right visual field for participants) has less of a negative impact on ratings. If people subconsciously expect human chests to be larger on an individual's left, then asymmetry may be less off-putting when it results in an individual with a larger left side. However, data on breast sizes suggest that while asymmetry within an individual is common, at a population level, breasts show no tendency to be larger on one side of the body or the other (no overall difference between left and right Manning et al. 1997; slightly larger in left Hussain et al. 1999; on average larger on the right Brown et al. 2008).

The impact of the type of image

The fifth chapter of this thesis assessed the impact of the different types of images used in previously published studies to examine breast size and attractiveness or health. This analysis showed that photographic images were rated more highly for attractiveness and health than line drawings or silhouette images. This finding is important because most studies have worked under the assumption that such simple drawings convey sufficient detail and are appropriate to use in attractiveness studies.

Ecological validity

Swami (2009) discussed the idea of ecological validity – that the images being used in these studies may not well represent women in the society where the study is being performed. If attractiveness studies are to be valid, they should reflect how real people are viewed by their peers. Singh's (1993) original images have been altered and used in a wide variety of situations. While a lot of the work has been done in Western countries, Singh's original images have sporadically been used to test ideas about female attractiveness in other societies. For example, Wetsman and Marlowe (1999) used Singh's images to examine mate preference in the Hazda. Singh's images show a woman with long hair loose hair, and wearing a Western one-piece bathing suit (see Figure 5.3 for an example). Such images are unlikely to well represent women outside of the specific Western circumstance. This point is illustrated by the fact that when Marlowe et al. (2005) used images more appropriate to the Hazda culture, they obtained very different results in regards to preferences for waist-to-hip ratios (0.6), while Singh's images (Wetsman and Marlowe 1999) produced a very slight and non-significant preference for a 0.9 waist-to-hip ratio over a 0.7 image.

In selecting images for the experiments in this thesis, care was taken to make the image ecologically valid. Images of young women were selected as most appropriate to the age

group likely to comprise the majority of the participants (despite attempts to widen the sample). The women in the images had skin tones that varied from “peaches and cream” to tanned; both tones are common in New Zealand. The women both had a conventionally Western European body shape – without steatopygia (fat deposits on the buttocks) and were of “normal” proportions.

Despite these attempts at maximum “ecological validity” for the target audience, no image in the two large scale studies was given an average rating above four out of a possible five for attractiveness (average ratings for each image are available in Appendices 3-5). The highest average attractiveness rating was given to the symmetrical control in the symmetry study (3.84/5). The health and nurturance ratings gave similar results. It is unclear how scores at the high end of the ratings scale could be encouraged more strongly; the guidelines suggested ratings of “five” for images that were “extremely” attractive/healthy/nurturing. Such low ratings have been noted before (Swami et al. 2009), and attempts to remove this effect (by allowing the study participant to preview all the images to allow them to calibrate their ratings to the specific image set) have proven unsuccessful (Rilling et al. 2009). Rilling et al. (2009) suggested that this effect may be due to exposure to unusually attractive women in the mainstream media, or that the low scores are reflective of the fact that the women used in their sample were not in good enough physical condition to warrant maximum ratings.

Modification of photographs

Three independent studies (Dixon et al. 2009; Grundl et al. 2009; and study 1, this thesis) found that altering the breast size in photograph quality images (to be either larger or smaller) reduces attractiveness. Two possible explanations spring to mind. The first is that the photo-manipulation is not being performed well enough to hide its

presence. This would be unsurprising; while informal questioning of my participants indicated they had trouble telling which images were the original, photo-manipulation is, nonetheless, a learned skill. Even professionals often publish photographs that are obviously altered and with unrealistic proportions. A second possibility is that when breast sizes are changed, they appear out of proportion to the original body, and this lack of proportion reduces attractiveness. This is a problem that completely line drawn images may not be as prone to, as all of the proportions are artificial.

Impact of the study population

Studies of this type often use the convenient sample of undergraduate students for their study sample; this is a yearly renewed source of relatively naïve potential subjects and many researchers make use of it (for example Singh 1995; Singh and Young 1995; Dixon et al. 2007; Little et al. 2008). However, the relative homogeneity of this sample results in qualitatively homogenous results, and the appropriateness of this tactic has been discussed repeatedly (for discussion and second order meta-analysis see Peterson 2001). This thesis, therefore aimed to recruit from outside this standard group as well as from within it. To that end, participants were recruited opportunistically from a wide range of social groups. The aim was to get a more representative sample of human preferences, although the study was restricted by logistic concerns to New Zealand.

The attempts to recruit a wider than usual sample appeared to be successful, as shown by a comparison of age data between this thesis and some previously published reports that used only student participants. The study of breast size and areola colour had an overall standard deviation for the ages of 5.3; in the asymmetry study the standard deviation of age was 8.1. In contrast, studies using primarily university students have reported standard deviations of the mean age of 3.28 (Furnham et al. 2006), 5.56 and 3.44 (Rilling et al. 2009).

No effect of sex of the participant

Studies 1 and 2 in this thesis used sex of the participant as one of the main effects in the initial analysis, as it was considered reasonable to expect that male's and female's reactions to breasts would differ. The impact of the sex of the participant has been shown to be a significant factor determining ratings in some studies of human attractiveness (for example Horvath 1981; Furnham et al. 1998; Furnham et al. 2006) but not in others (Krantz et al. 1997; Furnham and Swami 2007). However, the analyses of variance conducted in this thesis showed no significant effect of the sex of the participant, nor was this factor involved in any strongly significant interactions. The data for males and females were accordingly pooled.

While men may use breast morphology to evaluate their potential mate choices, women also have access to these signals and may make use of them. Women could potentially use the information conveyed by breast morphology to assess the quality of other women in the environment and adjust their mating strategies accordingly. There is evidence that this does occur; women prefer different levels of symmetry and masculinity in male faces depending on how attractive they rate themselves (Little et al. 2001). It is therefore not surprising that the studies in this thesis showed that women are as sensitive to signals of a woman's mate quality as men were.

Non-naivety and the halo effect

An effort was made to exclude participants who were likely to have explicit knowledge of the theories being tested. However, research on human sexuality is often reported in both pop-science and mainstream media outlets and it seems unlikely that most participants in these studies had avoided all exposure to such research. Self-selection is also a factor in this analysis; one would presume that those with an interest in and knowledge of a topic might be more likely to self-select to participate in a study about it when approached. In addition, some of the classes recruited were undergraduate

biological sciences classes at Victoria University of Wellington. Informal comments from participants indicated that many were well aware of the broad details of the theories being tested. The briefing given to participants attempted to override some of this knowledge, encouraging participants to answer honestly rather than supplying what they thought the “correct” answer might be.

It is unclear how non-naivety may have impacted the results in this study. Provided that all participants were providing ratings honestly, the effects should have been minimal. However, it is my feeling that non-naivety is likely to act primarily by exacerbating the “halo effect”, where people with one positive trait are assumed to have others, often strongly enough to override information received from other sources (Nisbett and Wilson 1977). This effect has been shown to be potentially important in attractiveness studies; ratings of health and attractiveness of images vary more between subjects than within subjects (Swami and Hull 2009). In both Study 1 and Study 2, the correlation between all ratings was both positive and statistically significant. Knowledge of evolutionary and sexual selection theory either through formal education or media exposure is likely to strengthen such correlations.

Recommendations for future work

Future work should take into account that not all images equally represent a human body. In the past, the relative ease of generating line drawings and silhouettes may have encouraged their use over photographs. However, with recent technological advances, photographic images are easy to generate and modify in order to examine the impact of any number of traits. Photographs also gain higher ratings compared to line drawings and may be more ecologically valid. Computer-based photographic techniques make it possible to accurately model skin tone and general morphology in cross-cultural studies. However, if digitally altered photographs are to be used properly, the modifications

must be done in a way that hides their presence. For example, it has already been discussed that several studies have reported that the original breast image was most attractive (Dixson et al. 2009; Grundl et al. 2009; and study 1, this thesis). These studies cannot distinguish which aspect of these images was actually preferred: the absolute size of the breast, the breasts proportion relative to the rest of the body, or the breasts lack of digital modifications. Further research should include, perhaps as part of the pilot research, an investigation into how well the modifications have been performed.

Signals provided by the morphology of the breast, as well as selection for properly receiving and interpreting them, evolved in hominid populations almost certainly without substantial clothing. Many signals, for example information transmitted by pigmentation of the areola or the shape of the breast, are altered or obscured by clothing. However, many researchers persist in using clothed images even while assessing traits that may be concealed by clothes. For example, Smith and colleagues (2007) correlated waist-to-chest ratio to attractiveness on female models wearing a camisole which covered the torso to just above the thinnest part of the waist. Despite being described as “unsupportive” this camisole likely altered the shape and perceived size of the breast and, if the sample images published are representative, partially obscured the exact height and size of the waist. Clothing may be a necessary compromise when trying to recruit women to be subjects in such studies. However, drawing clothing onto completely artificial images, as was done in Tantleff and Thompson’s (1992) and Singh’s images (for example Singh 1995; Singh and Young 1995) is unnecessary and reduces accuracy.

When designing images for such studies, it must be remembered that participants are being asked to make ratings based on the differences between the presented images, not

the same differences on real people. The validity of the analysis is reliant on the changes being clearly conveyed and in a context which allows participants to judge the changes as they would on a real person. Moving beyond clothed images will allow image sets to be developed that convey the signals of interest more precisely.

Cross cultural and international replication

Some of the findings in this thesis have not been reported or explored in the literature before, such as the interactions between areola colouration and breast size (Chapter Three). Studies of asymmetry have generally compared asymmetrical to symmetrised versions of themselves; the finding that perception of symmetry is affected by the side chosen for alteration (Chapter Four) has not been shown before. Nor has the analysis of different types of images used in attractiveness studies (Chapter Five) been attempted before. These findings require replication to confirm the results. Future explorations of the pseudoneglect effect on ratings of asymmetric breasts could easily include an analysis of the handedness of participants.

If the interactions explored in this thesis are to be confirmed as “human” traits, as opposed to traits in members of individual cultures or populations, they must be replicated in as many disparate societies as possible. This replication should take into account cultural and morphological differences between the groups, and modify the images appropriately.

Replications should also attempt to control for prior knowledge of evolutionary theories and for exposure to the hyper-attractive women regularly shown in the Western mainstream media, as either of these could strongly impact impressions of attractiveness and the halo effect. Such controls are, it will be appreciated, very difficult to achieve in

an increasingly “globalised” world, where Westernised media are available to many cultures.

Breasts as a sexually selected feature

This thesis has investigated the sexual selection and evolution of human breasts, a derived feature in human anatomy and physiology. Using systematically modified photographs, this thesis investigated how changes in the morphology of the human breast resulted in changes in ratings of attractiveness, health, nurturance, sexual maturity and age.

The analyses reported here showed that people are sensitive to changes in breast size and changes in areola colouration. The first study showed that breasts *per se* are attractive; the images with flat chests but otherwise similar characteristics were rated much lower on all measures. Increasing breast sizes generally resulted in higher attractiveness ratings, except for the very largest sizes, which tended to be rated slightly lower. A similar pattern was seen for health ratings. Larger breasts resulted in the images being rated as more nurturing, more sexually mature and older. The impact of areola colour changed depending on the size of the breast; darker areolae resulted in lower ratings in the small and original breast sizes, but higher ratings in the largest breast size. Study 2 showed that images were given lower ratings for health and attractiveness if they are more asymmetrical, and that the effect of the modifications was stronger when carried out on the model’s left side (in the viewer’s right field of vision).

These changes are known to be related to reproductive success and fitness in women. Sensitivity to these signals could enable men to make accurate and efficient reproductive decisions, and help women accurately judge the quality of the competition.

Those who do so successfully could potentially have greater reproductive success, leading to selection for sensitivity to these traits. If males make reproductive decisions based on preferences educated by assessments of fitness (via attractiveness), traits that are attractive – namely, an intermediate breast size and symmetrical breasts might have been sexually selected for during human evolution.

Appendices

A1: Demographic Information Sheet

RESPONDENT INFORMATION

Please provide the information requested by checking the appropriate boxes. Then fill out the score sheet on the next page whilst looking at the images. Please do not discuss your choices and make them promptly- then hand in your questionnaire.

All information is confidential: your name is not required.

Your sex:

☐

MALE

☐

FEMALE

Your age:

(IN YEARS)

Ethnicity:

☐

Pakeha/European

☐

Maori

Other (Specify).

**Are you a Citizen
of New Zealand?**

☐

YES

☐

NO

A2: Example of Response Sheet taken from Study 1

IMAGE NUMBER	Attractiveness	Health	Nurturing	Sexual Maturity	Age (in years)
1					
2					

Attractiveness Score.

- 1 = Unattractive
- 2 = Slightly attractive
- 3 = Average
- 4 = Very attractive
- 5 = Extremely attractive

Health Score.

- 1 = Unhealthy
- 2 = Slightly healthy
- 3 = Healthy
- 4 = Very healthy
- 5 = Extremely healthy

Nurturing Score.

- 1 = Unnurturing
- 2 = Slightly nurturing
- 3 = Averagely nurturing
- 4 = Very nurturing
- 5 = Extremely nurturing

Sexual Maturity.

- 1 = Preadolescent
- 2 = Adolescent
- 3 = Post adolescent
- 4 = Young adult
- 5 = Adult

A3: Mean Ratings Given to each image In Study 1

Image	Rating					
	Attractiveness	Health	Nurturing	Sexual Maturity	Age	
0%/Light	1.13 ± 0.405	2.22 ± 1.080	1.18 ± 0.496	1.36 ± 0.763	11.97 ± 3.591	
0%/Original	1.18 ± 0.519	2.25 ± 1.059	1.24 ± 0.618	1.47 ± 0.867	12.21 ± 3.738	
0%/Dark	1.19 ± 0.505	2.2 ± 1.027	1.24 ± 0.604	1.43 ± 0.766	12.27 ± 3.479	
80%/Light	2.86 ± 0.88	3.49 ± 0.845	2.45 ± 0.749	3.39 ± 0.907	19.40 ± 3.208	
80%/Original	2.64 ± 0.815	3.26 ± 0.891	2.43 ± 0.719	3.28 ± 0.909	19.39 ± 3.380	
80%/Dark	1.67 ± 0.737	2.1 ± 0.976	1.98 ± 0.885	3.13 ± 1.149	19.18 ± 7.062	
100%/Light	3.56 ± 0.849	3.73 ± 0.794	3.22 ± 0.731	3.95 ± 0.721	20.73 ± 3.335	
100%/Original	3.42 ± 0.840	3.65 ± 0.814	3.05 ± 0.735	3.81 ± 0.861	20.39 ± 3.041	
100%/Dark	3.12 ± 0.858	3.47 ± 0.873	3.03 ± 0.856	3.75 ± 0.938	20.76 ± 4.289	
120%/Light	3.07 ± 0.985	3.5 ± 0.814	3.61 ± 0.762	4.37 ± 0.696	23.24 ± 3.954	
120%/Original	3.42 ± 0.898	3.59 ± 0.791	3.63 ± 0.805	4.41 ± 0.724	23.29 ± 3.851	
120%/Dark	3.48 ± 0.907	3.65 ± 0.808	3.82 ± 0.781	4.58 ± 0.668	24.41 ± 4.315	

Average ratings given to each of the twelve images in the breast size and areola colour study, Chapter 3. ± Standard Deviation of the sample

A4: Mean Ratings Given to each image In Study 2

	Rating	
	Attractiveness	Health
Original Image	2.94±0.900	3.03 ± 0.966
Symmetrical Control	3.84±0.859	3.84 ± 0.901
Right		
Position Adjustment		
1%	3.385±0.906	3.52 ± 0.868
2%	2.735±0.817	2.99 ± 0.856
3%	1.895±0.719	2.31 ± 0.888
4%	2.26±0.892	2.66 ± 0.974
Volume Adjustment		
102.5%	3.68±0.860	3.66 ± 0.872
105%	3.58±0.904	3.69 ± 0.876
107.5%	2.99±0.808	3.1 ± 0.821
110%	2.935±0.874	3.09 ± 0.869
Left		
Position Adjustment		
1%	3.265±0.848	3.39 ± 0.855
2%	2.525±0.850	2.84 ± 0.901
3%	1.985±0.811	2.43 ± 0.905
4%	1.7±0.723	2.12 ± 0.889
Volume Adjustment		
102.5%	3.775±0.841	3.81 ± 0.865
105%	3.54±0.879	3.58 ± 0.871
107.5%	2.595±0.821	2.79 ± 0.871
110%	2.545±0.861	2.78 ± 0.882

Average ratings given to each of the twelve images in the breast asymmetry study, Chapter 4. ± Standard Deviation of the sample.

A5: Average Ratings Given to each image in Study 3

Image	Rating	
	Attractiveness	Health
Dixson et al. 2009	3.30 ± 0.777	3.54 ± 0.900
Grundl et al. 2009	3.54 ± 0.650	3.68 ± 0.747
Singh 1995, study 2	2.46 ± 0.869	2.97 ± 0.726
Swami and Hull 2009	2.78 ± 1.158	3.32 ± 0.944
Thompson and Tantleff 1992	2.78 ± 0.712	3.46 ± 0.691
Study 1, this thesis	3.51 ± 0.989	3.70 ± 0.812
Wiggins et al. 1968	2.30 ± 0.740	2.59 ± 0.865
Furnham et al. 2006	2.49 ± 0.901	3.03 ± 0.799
Gitter et al. 1983	2.43 ± 0.959	2.81 ± 0.877
Singh 1995, study 1	2.38 ± 0.861	2.49 ± 0.870
Furnham et al. 1990	2.62 ± 0.861	3.00 ± 0.782

Average ratings given to each of the twelve images in the image comparison study, Chapter 5.. $\pm$ Standard Deviation of the sample.

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