The role of gender in face recognition

Jenny Rehnman

Stockholm University

The cover illustration is reprinted with permission from Arbetsmiljöupplysningen

Doctoral dissertation, 2007
Department of Psychology, Stockholm University
Jenny Rehnman, Stockholm 2007
ISBN 91-7155-384-3
Printed in Sweden by US-AB, Stockholm 2007
Distributor: Stockholm University Library

Abstract - English

Faces constitute one of the most important stimuli for humans. Studies show that women recognize more faces than men, and that females are particularly able to recognize female faces, thus exhibiting an own-sex bias. In the present thesis, three empirical studies investigated the generality of sex differences in face recognition and the female own-sex bias. *Study I* explored men's and women's face recognition performance for Bangladeshi and Swedish female and male faces of adults and children. Result showed sex differences, favoring women, for all face categories. *Study II* assessed boys' and girls' ability to recognize female and male faces from two age- and ethnic groups. The result demonstrated that girls recognize more faces than boys do, but that no sex differences were present for Swedish male faces. The results from *Study I and II* consistently demonstrate that females show reliable own-sex biases independent of whether the female faces were young, old, or of Bangladeshi or Swedish origin. In an attempt to explain the mechanisms of sex differences in face recognition and the female own-sex bias, *Study III* investigated men's and women's recognition performance for androgynous faces, either labeled "men", "women", or "faces". The result showed that women told to remember "women" recognized more faces than women told to remember faces labeled "men" or "faces", and that sex differences were present for androgynous faces, regardless of the label. Based on these findings, it is suggested that females' attention is in particular directed towards other females, resulting in an own-sex bias. It is also suggested that there may be a difference in females' and males' orientation toward other individuals. This difference can have a biological base, which together with socialization may result in sex differences in face recognition.

Keywords: Face recognition, Sex differences, Own-sex bias, Own-group bias, Attention, Biology, Socialization, Psychobiosocial

Sammanfattning – Svenska

Ansikten utgör troligtvis de allra viktigaste objekten för människors sociala samspel. Forskning visar att kvinnor generellt kommer ihåg fler ansikten än män och att flickor och kvinnor är särskilt bra på att minnas andra kvinnors ansikten - de visar en ”own-sex bias”. ”Own-sex bias” innebär att personer är bättre på att minnas ansikten av individer av samma kön i jämförelse med ansikten av personer av motsatt kön. Ett fåtal tidigare studier har undersökt könsskillnader i ansiktsigenkänning. I avhandlingen undersöks hur allmängiltig könsskillnad i ansiktsigenkänning är och hur allmängiltig kvinnlig ”own-sex bias” är. I *Studie I* studerades kvinnors och mäns förmåga att minnas bangladeshiska och svenska flick-, pojk-, kvinno- och mansansikten. Resultatet visar att kvinnor minns fler ansikten oavsett kategori. I *Studie II* undersöktes flickors och pojkars förmåga att minnas bangladeshiska och svenska flick-, pojk-, kvinno- och mansansikten. Resultaten i *Studie II* replikerar resultaten från *Studie I*, då flickor kände igen fler ansikten än vad pojkar gjorde. Flickor och pojkar presterade på liknande nivåer för svenska pojk- och mansansikten. Resultaten från *Studie I* och *II* visar också entydigt att flickor och kvinnor är bättre på att minnas flick- och kvinnoansikten än pojk- och mansansikten oavsett vilken ålder och etnicitet ansiktena hade. Förklaringar till könsskillnader i ansiktsigenkänning och till kvinnors ”own-sex bias” saknas. I *Studie III* undersöktes därför kvinnors och mäns förmåga att minnas androgyna ansikten, benämnda ”kvinnor”, ”män” eller ”ansikten”. Resultatet visade att kvinnor i högre grad mindes ansikten som benämndes ”kvinnor”, än ansikten som benämndes ”män” eller ”ansikten”. Kvinnor var också bättre än män på att minnas androgyna ansikten oavsett benämning. Dessa resultat diskuteras utifrån antagandet att kvinnor i högre grad än män riktar sin uppmärksamhet mot andra människor och i särskilt hög grad mot andra kvinnor. Det föreslås att skillnader mellan män och kvinnor vad gäller orientering mot andra individer kan ha en biologisk grund, som tillsammans med socialisering kanske resulterar i könsskillnader i ansiktsigenkänning och i ”own-sex bias”.

Nyckelord: Ansiktsigenkänning, Könsskillnader, Own-sex bias, Own-group bias, Uppmärksamhet, Biologi, Socialisering, Psychobiosocial

Acknowledgements

In many respects doing a PhD degree is like undertaking an adventurous journey. This has definitely been true in my case. Undoubtedly, a journey like this is not possible to complete without many excellent companions. And I have had that…

First, and most of all, I had a wise supervisor, *Agneta Herlitz*, to whom I owe many thanks. Without her this journey never would have started, nor had been finished. She helped me stay on the right track and at a steady pace. Importantly, her ability to see the bigger picture and always being available for support and guidance has been of utmost value during this journey.

I also had the fortune to have a co-supervisor, *Torun Lindholm*, to whom I am grateful for all the encouraging and insightful comments on both big and small issues, and for guiding me towards important research paths, which would have been left untravelled without her.

Towards the end of the journey, *Ann-Charlotte Smedler* and *Björn Lyxell* shared their knowledge and gave me excellent comments, helping me improve the finalized version of the dissertation before crossing the finishing line…

The journey would not have been the same without the bright and cheerful colleagues I have had the opportunity to share it with. To all coworkers at ARC–Äldrecentrum, I am truly grateful to you for making ARC–Äldrecentrum such a friendly workplace and an excellent environment for learning and conducting research. Specifically, I want to thank Stuart MacDonald for your never ending expertise and willingness to share it, and for your positive spirit, which rubs off on everyone. Other special thanks goes to *Anna-Karin Berger, Joachim Gavazzeni, Katie Palmer, Petra Thilers,* and *Sari Karlsson* for always giving me your helping hands and heads, and importantly, thanks for all the sick jokes and the exuberated laughs that I have shared with you during the journey. You all made it more than durable; you made it enjoyable!

Thanks also to the former *"5th floor gang"* for fun chats at coffee breaks and to *Britt-Marie Gulbrandsen, Cecilia Larsson, Christian Lynghaug*, *Helene Hägglund, Maria Wahlberg, Malin Hallberg, Peter Axelsson, Sofia Österman, and Zoltan Pethö* for excellent help with all practicalities. You have definitely been the service team this journey needed! I also want to thank *Lars Bäckman* for valuable comments on Study III, and to all members of the psychology group at ARC, especially *Erika Jonsson-Laukka* for the support at the finish. Many thanks also go to all *PhD students, administrative personnel* and *teachers* at Stockholm University. I will remember you for the interesting and fun talks we have had during courses, lunches, meetings, and parties and for the excellent help you all have provided when it was needed.

My gratitude also goes to everyone who took their time to take part in the studies, and to all the teachers who helped make the data collection possible. In addition to the Psychology Department at Stockholm University this journey was supported with grants from The Swedish Research Council and the Bank of Sweden Tercentenary Foundation awarded to *Agneta Herlitz*.

To all my friends and family members I want to say "thank you" for believing in me when I, myself, was in doubt. Special thanks go to my sister *Lisa* who actually read the dissertation when it was unreadable and who endured my agony during the last part of the journey. Some members of my family were not able to participate in this particular journey in my life. They have still, in their own right, given me the opportunity to complete it. Most of all my gratitude goes to my grandmother *Bollan*, who was sense and wisdom personified but without knowing it herself.

Last, my heart filled gratitude goes to my husband *Sven-Erik*, who undoubtedly, every day, gives me his endless love and respect during this, and other important journeys in life.

I hope and wish that we will meet again on another journey and on a road not yet taken!

jenny

To Life!

List of studies

The present doctoral thesis is based on the following empirical studies, which will be referred to by their Roman numerals.

I. Rehnman, J., & Herlitz, A. (in press). Women remember more faces than men do. *Acta Psychologica.*

II. Rehnman, J., & Herlitz, A. (2006). Higher face recognition ability in girls: Magnified by own-sex and own-ethnicity bias. *Memory, 14* (3), 289 - 296.

III. Rehnman, J., Lindholm, T., & Herlitz, A. *Why women remember women – Gender labeling of androgynous faces produces a female own-sex bias.* (Manuscript submitted for publication).

Contents

1. General introduction

Faces probably constitute one of the most prominent and important stimuli for humans, and many of our everyday social interactions depend on our ability to recognize people's faces. That we, even after decades, can recognize both our friends' and family members' faces must be an ability highly valuable for our survival. But why then, do men and women not seem to remember faces equally well? This is one of the questions that will be explored in this thesis.

1.1. Why study sex differences in face recognition?

Although the interest in face recognition is not new (Sugisaki & Brown, 1916) and research has rendered a vast amount of results, there are still unresolved issues. For example, in witness settings, the face recognition deficit that people show for other-race faces is conceded. Evaluating the presence of a similar effect for own-sex recognition is therefore interesting both from a theoretical and applied perspective. Moreover, by combining research on sex differences and face recognition, important information can be added to theories in both research fields. The role of gender in face recognition can thus be studied both from a sex differences perspective and an own-group bias perspective.

The history and controversies of cognitive sex differences have long shared a common path. In spite of this, it is currently widely accepted that men and women generally differ in some cognitive abilities although the causes of these differences have largely remained a source of controversy (Halpern, 2000). Studies have shown that participants' mere expectations of sex differences can affect the empirical result (Steele, 1998). However, studies of face recognition may benefit from the fact that they probably are less influenced by people's stereotypical expectations of sex differences than are sex differences in other tasks, for which research findings have been popularized to a greater extent. It should be stated clearly that the present thesis has not set out to answer the question of whether sex differences in face recognition are good or bad, or whether they should be accepted or changed. Instead, the aim of this thesis was to study whether, where, and why sex differences are present in recognition of neutral (i.e., non-emotional) faces.

1.2. Terminology

The term "gender" has generally been associated with a social psychological and a social constructionist perspective on sex differences, whereas the term "sex" has generally been adopted when the research has applied a biological perspective (Gergen & Davis, 1997; Magnusson, 2002; Unger & Crawford, 1996). These two views on the origin of sex differences are based on the assumptions that either experience and sociocultural constructions (i.e., the social constructionist view) or biological differences between men and women cause sex differences. In this thesis, I have instead chosen to adopt the psychobiosocial framework for explaining sex differences, which states that the interaction between biology and experience neither can be, nor should be ignored (Halpern, 2000). Within this thesis, it is argued that both biology and experience jointly can be, and probably are, the bases of the result of sex differences in face recognition. Therefore, the described assumptions associated with use of the terms "gender" and "sex" do not apply to the present thesis. However, use of the word gender is sometimes generally more appropriate (Magnusson, 2002). Both the term "gender" and "sex" are used interchangeably throughout the thesis and empirical articles. Similarly, although the terms "ethnicity" and "race" do not have the same meaning (Colman, 2003), these terms are also used interchangeably.

1.3. A brief overview of the present thesis

The following sections will introduce the research of interest in the present thesis. This includes an introduction to research on memory, face processing and face recognition, followed by a section on sex differences in cognitive abilities and a section describing the findings relating to sex differences in face recognition. Following this are the aims of the thesis, and the specific aims and summaries of the enclosed studies. Last, the results are discussed and evaluated in relation to past and more recent evidence and in relation to theories on face recognition and sex differences. Thereafter follow a section on the studies' limitations and some future directions for research on sex differences in face recognition. The thesis closes with a summary and a concluding remark.

2. Memory

The research in this thesis was carried out within a general cognitive framework. The term cognition stems from the Latin word *cognoscere*, meaning "to get to know" (Colman, 2003). Scholars working within the cognitive framework have tried to answer psychological questions regarding, for example, how and why we remember, learn and forget the things we do. Other issues of interest concern how we perceive, think, interpret, and make sense of the world around us. The present research is carried out within the fields of memory (i.e., face recognition) and individual (i.e., gender) differences research. This particular background has implications for how the research is carried out and how the results are interpreted. The study of individual differences is based on the assumption that differences are theoretically valid, can give important information, and contribute to our theoretical understandings over and above general mean level performance (Thompson-Schill, Braver & Jonides, 2005) Within the field of cognition and memory, it is further assumed that people store mental representations of information about the world, which is expressed and can be measured through our behavior.

2.1. Theories of memory

Evidence has shown that the concept of memory cannot be thought of as a unitary construct (Schacter & Tulving, 1994). Some researchers have focused on memory as a process in which aspects of encoding, storage and retrieval of memories each play a separate and important role in the memorizing process (e.g., Blaxton, 1995; Roediger, 1990). Research has shown that manipulation of any of these processes, such as making encoding more elaborate or giving a cue at retrieval, can affect memory performance (Craik & Tulving, 1975; Mäntylä & Nilsson, 1988; Stein & Bransford, 1979). Research has also shown that when the encoding of stimuli is done in a more meaningful way, rather than less, memory performance is elevated (Craik & Lockhart, 1972). In addition, material that has been processed in a self-generated elaborative manner is remembered with higher proficiency. There is also evidence showing that we more accurately remember information that is important to us and that we can personally relate to (Rogers, Kuiper & Kirker, 1977; Symons & Johnson, 1997).

Other researchers have focused on the view of memory as a system (see Schacter & Tulving, 1994). The basic idea of the structure of memory as a system is that memories can be divided and classified into separate entities, each encompassing qualitative differences (Squire, 1992; Tulving, 1983). The basis for the division of memories into systems is that memories, as assessed by different tasks, show dissociate (distinct) patterns. Although in some respects overlapping, the memory systems also draw on different areas of the brain (Cabeza & Nyberg, 2000; Nyberg, Forkstam, Petersson, Cabeza & Ingvar, 2002).

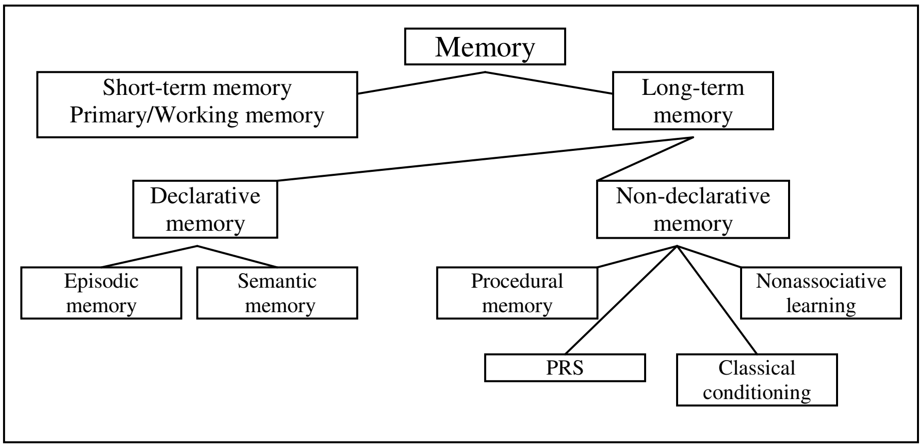

Figure 1. Schematic overview of memory as a system (adapted from Nyberg, 2002)

2.1.1. Memory systems

The memory systems view divides memories according to their temporal features (see Figure 1). *Short-term memory* can be divided into *primary* memory, where information can be held on-line, without any active manipulation, and into *working memory*, where an ongoing active process is needed to hold a limited amount of information (Baddley, 1992; Baddley & Hitch, 1974). Working memory is viewed as a multicomponent model which encompasses four different components (Repovs & Baddley, 2006); the central executive, involved in manipulation and integration of information, the phonological loop and the visuospatial sketchpad which hold and have mechanisms for maintenance of phonological, visual, and spatial information respectively. There is also an episodic buffer which is considered to be a multi-modal store involved in the formation of information from the different subsystems into an integrated representation. In contrast to short-term memory, *long-term memory* storage can hold an infinite amount of information. Further, long-term memories are divided depending on their declarative (i.e., explicit) and non-declarative (i.e., implicit) characteristics (Nyberg, 2002; Schacter & Tulving, 1994).

Declarative memory encompasses the types of memories that we are consciously aware of and can verbalize. Declarative memory can be divided into *episodic* and *semantic* memory, where episodic memories contain memories with a self-referential component such as the ability to remember “what”, “when” and “where” something was learned (Tulving, 1983, 1993). These temporal and spatial cues allow us to mentally travel back in time to when and where the encoding of the specific memory took place (Tulving, 1983, 1993). Face recognition is one form of episodic memory and one way to test episodic memory is to present a list of faces to participants and instruct them to remember the faces for a later recognition task. Later the same faces are randomly intermixed with a set of faces not shown earlier and participants are asked to judge whether or not they recognize the earlier presented faces.

Semantic memory can be described as the common knowledge and facts that a person has acquired in the absence of specific temporal and spatial cues (Tulving, 1983, 1993). For example, in order to know that the name of the King of Sweden is Carl Gustaf, it is not necessary to know how, where and when you learned that. Moreover, studies on aging have consistently shown developmentally dissociate patterns for these two domains of declarative memory where semantic memory show much less detoriation across age than episodic memory does (e.g., Spaniol, Madden & Voss, 2006)

Within the non-declarative memory system, a distinction is made between *procedural memories* and the *perceptual representation system* (i.e., *PRS).* Procedural memories reflect our knowledge of actions and skills and encompass highly automatic performances such as swimming or riding a bike (Cohen & Squire, 1980; Squire, 1992). The perceptual representation system encompasses the concept of *priming*, where foregoing exposure to one stimulus facilitates faster access and/or more accurate recognition of an upcoming stimulus. In the absence of conscious awareness, the prime, for example, the King of Sweden, later facilitates faster access to the Queen of Sweden’s face, which shares a strong association with the prime (Bruce & Valentine, 1986). A recent study showed that the priming effect was sustained even 17 years after the initial exposure of faces (Mitchell, 2006).

Two additional domains within the declarative memory systems are *classical conditioning* where for example an association between otherwise neutral stimuli and positive stimuli is learnt. Thereafter the neutral stimuli elicts the response which before was only elicted from the positive stimuli. *Nonassociative learning* is involved in habituation in which repeated exposure to stimuli makes the individual insensitive, so that the response to the stimuli decreases (Nyberg, 2002).

***In summary*:** Both the processing view of memory and the systems view of memory are needed to explain the vast experimental behavioral and functional (i.e., brain activation) data, and contribute in their own right to our theoretical and practical knowledge of memory (Roediger, Buckner & McDermott, 1999). Also the data within this thesis must be considered both from a processing view (e.g., processes at encoding of faces) and from a system view as sex differences have been reported on a range of different episodic memory tasks (e.g., Herlitz, Nilsson & Bäckman, 1997).

3. Faces as stimuli

It is probably fair to say that humans are incredibly good at discriminating between and recognizing different faces. Our exquisite face recognition ability has most likely served human survival particularly well throughout evolution. It is remarkable how we can recognize our grandmother from an old school picture when she was only seven years old. Even after decades, which have exerted inevitable influences on the face, people are able to successfully recognize old school friends (Bahrick, Bahrick & Wittlinger, 1975). Already shortly after birth, faces, and material with a face-like configuration, invoke particular interest, so that infants' attention is more directed towards faces than towards other complex visual stimuli (Johnson, Dziurawiec, Ellis & Morton, 1991; Macchi Cassia, Keufner, Westerlund & Nelson, 2006; Macchi Cassia, Turati & Simion, 2004; Morton & Johnson, 1991; Valenca, Simion, Macchi Cassia & Umiltà, 1996).

3.1. Face processing

Humans can discriminate faces from other objects in a very short time, within 100 ms, and faces are attended to more rapidly than are other objects (i.e., 100 versus 200 ms) (Bentin, Allison, Puce, Pererz & McCarthy, 1996; Pegna, Khateb, Michel & Landis, 2004). Although researchers do not agree on what the underlying mechanisms are for some of the face recognition effects, faces are oftentimes considered to be special in comparison to other visual stimuli (see e.g., Rakover & Cahlon, 2001, for an overview).

This "*specialness*" stems from several lines of research showing that faces, in comparison to other visual stimuli such as words and houses, are processed more holistically. Face processing is also more sensitive to the structure, spatial lay-out, and configural relationship displayed between the facial features (i.e., distance from nose to eyes and the relational layout between the facial features) than is processing of other visual objects (Robbins & McKone, in press; Tanaka & Farah, 1993; Tanaka & Sengco, 1997; Young, Hellaway & Hay, 1987).

The evidence that faces are processed more holistically and depend less on feature-by-feature processing, in comparison to other stimuli, has been experimentally investigated in a paradigm called *inversion*. The inversion effect can be described as the difference in ability to recognize stimuli depending on whether they were initially seen inverted (i.e., for faces with the chin up) or upright (i.e., in its normal position). The inversion effect has shown that recognition performance for faces suffers more from inversion than does performance on other types of visual stimuli (Valentine & Bruce, 1988; Yin, 1969). The inversion effect is considered to interrupt the configural completeness of the face schema. Hence, less access to the face's configural information worsens the ability to process the face optimally (Rhodes, Brake & Atkinson, 1993).

Further evidence of why face processing seems special, derives from the ability to process and remember separate facial features (e.g., a nose). The feature is more accurately remembered when it is presented as part of a whole face at encoding than when presented in isolation (Farah, Wilson, Drain & Tanaka, 1998; Tanaka & Farah, 1993), demonstrating that processing of individual facial features is more optimal within a whole-face context. Other research has shown that feature-by-feature processing also contributes to the ability to process and remember faces (Sergent, 1984). The evidence presented above has led researchers to conclude that faces are unique in the sense that access to facial configuration is more important in face processing than in processing of other visual stimuli, although it is more a matter of degree than a dichotomy (Rakover & Cahlon, 2001).

Evidence from both functional (i.e., functional magnetic resonance imaging techniques; fMRI) and clinical studies lend support to the notion that face processing is special. Studies using fMRI have shown that a substantively stronger pattern of activity is found in a specific area in the brain, often referred to as the fusiform face area (FFA), when individuals view faces than when they view other objects (e.g., Gauthier, Tarr, Anderson, Skudlarski & Gore, 1999; Kanwisher, McDermott & Chun, 1997). The FFA is generally located in the mid-fusiform gyros in the occipitotemporal lobe (Kanwisher et al., 1997; Kanwisher, Stanley & Harris, 1999; McCarthy, Puce, Gore & Allison, 1997). Studies have shown that persons diagnosed with the clinical syndrome prosopagnosi (face blindness) can be explicitly insensitive to facial information and often show lesions in corresponding brain areas (Barton, Press, Keenan & O'Connor 2002; Farah, 1990; Farah, McMullen & Meyer, 1991).

Others have argued that faces are not really a special stimulus per se (e.g., Diamond & Carey, 1986; Gauthier, Behrmann & Tarr, 1999; Gauthier & Bukach, in press), but that the effects found for faces instead depend on the vast knowledge that humans exhibit with regard to this stimulus category. The *face-expertise* theory states that face processing is special because very extensive knowledge is needed to make the fine-grained within-category discrimination among faces. Diamond and Carey (1986) showed that when people had high expertise, in the area of dogs, and when stimuli (i.e., different dogs) shared common and prototypical information, inversion effects also occurred for these stimuli (but see also Robbins & McKone, in press). More recent studies have shown that activation of the FFA is found in experts on birds and cars (Gauthier, et al., 2000). This adds to the idea that face stimuli are "*special*" owing to the vast amount of faces that humans encounter during a lifetime.

3.2. Gender categorization

In order to decide which incoming stimuli to pay attention to, humans must select which stimuli are salient and important enough for further processing (Palermo & Rhodes, in press). However, it is not always necessary to attend to the individuating information of stimuli and processing of stimuli at a categorical level requires less processing (Grill-Spector & Kanwisher, 2006). Gender categorization, which is, deciding whether a face belongs to a man or a woman, is performed with high accuracy. Bruce et al., (1993) showed that 96% of faces were correctly categorized as being female or male. Although people are generally very accurate at discriminating between female and male faces, the reasons why they are able to do so are not well understood (Burton, Bruce & Dench, 1993). In a series of experiments, Bruce and colleagues (1993) showed that several factors contributed to the characteristics "femaleness" and "maleness" of faces. Features such as eyebrows, nose, and chin, as well as configural information in both 2D and 3D planes were important for accuracy in the categorization of faces as female or male. Several studies have shown that facial features differentially contribute to face gender. Eyes and brows, followed by jaw and chin, are the most prominent features in determining face gender (Brown & Perrett, 1993; Yamaguchi, Hirukawa & Kanazawa, 1995).

3.3. Face recognition

The vast research on face recognition has shown that many factors contribute to why a person's face is successfully remembered. Face recognition is commonly investigated using sequential presentation of a set of faces during the period of a few seconds (e.g., 3 sec). After a retention-interval between a minute and several days, the same faces are sequentially viewed again, intermixed with a set of faces not presented in the initial viewing. Participants are asked to decide whether the seen faces were present in the list by completing a yes–no recognition test (see Rakover & Cahlon, 2001, for examples of different common experimental face paradigms). From the yes-no recognition test, using information from *hits* (i.e., correctly recognizing a stimulus presented earlier) and *false alarms* (i.e., mistakenly recognizing a new stimulus as old), accuracy of the performance can be extracted and an unbiased measure of the recognition performance can be computed. With an unbiased measure of performance accuracy, such as *d'* (d-prime), the amount of guessing is taken into account (see e.g., Macmillan & Creelman, 2004).

The main conclusions from face recognition research are related to general findings observed for other types of memory. For example, when a face is more distinct (i.e., stands out in a crowd of faces), it is more accurately remembered (e.g., Going & Read, 1974; Light, Kayra-Stuart & Hollander, 1979; Valentine & Bruce, 1986a). A high degree of variability between faces within a given set is found to enhance face recognition performance (Brown & Lloyd-Jones, 2006). Longer exposure time (Laughery, Alexander & Lane, 1971), and more elaborate encoding, such as categorizing faces according to their psychological properties (e.g., how honest is the person) in contrast to their physical properties (e.g., race categorization), have resulted in greater recognition accuracy (Bower & Karlin, 1974; Winograd, 1978). Classifying faces on the basis of their psychological properties is considered to entail more elaborative processing, resulting in more accurate recognition (Winograd, 1981). Researchers have interpreted this as indicating that faces are processed more in depth when the face is "personalized". A shorter time interval between the presentation and the test and the degree of concordance between stimuli at encoding and retrieval are also factors that contribute to accuracy in face recognition (Shapiro & Penrod, 1986).

However, one phenomenon called *verbal overshadowing* is face-specific. When faces are given a verbal description, the recognition performance is less accurate as compared to when no verbal description of the face is produced (Schooler & Engstler-Schooler, 1990). The effect is thought to depend on disruption of the global (i.e., the configural and/or holistic) processing, which is known to decrease face recognition performance (Macrae & Lewis, 2002). Successful face recognition ability also depends on factors related to the person performing the task. Consistent with findings of children's memory performance, younger children are generally less able to remember faces than are older children and adults, and adult levels of performance are reached around adolescence (Carey, Diamond & Woods, 1980; Leder, Schwarzer & Langton, 2003).

In order for a face to be identified and perceived as a face, the structural information such as contrasts and colors attained from the face need to be organized into a whole face representation. One model of face processing and recognition is the Bruce and Young (BY) model (Bruce & Young, 1986). The BY model states that facial information is extracted from the face in view and compared to the stored representation of the face in memory. If the similarity and concordance between the face seen and the face stored in memory is high, the face can be recognized as someone seen before. Another prediction from the BY model is that other information, such as the name and expression of the person, is processed in a separate parallel pathway, explaining why we can recognize a person's face without being able to recall her/his name (Bruce & Young, 1986). This model has further been modified by Haxby, Hoffman and Gobbini (2000; 2002) where the original BY-model is linked to recent neuropsychological information. Specifically, different parts of the brain are found to be involved at different hierarchical stages in face processing (see also Posamentier & Abdi, 2003, for a review).

Another face recognition model is the multidimensional face-space model that predicts and attempts to explain four important experimental face phenomena, including the inversion effect, the effect of distinctiveness, the caricature, and the own-race bias effect (Valentine, 1991). The multidimensional face-space is a metaphor for how faces are represented and stored in memory. The framework is based on the assumption that, throughout life, humans are exposed to innumerable faces that subsequently affect our ability to process and remember new faces. In the face-space, faces are thought to be represented as points or as vectors in a Euclidian multidimensional space. The different dimensions in "face-space" represent physiognomic features of the faces (e.g., such as race). Within the face-space framework, two different models are presented that differ in the way faces are thought to be represented within the face-space, which affects how the degree of similarity between faces is measured (Valentine, 1991). One model assumes that faces are stored as differences from a norm-face and the other theory assumes that faces are stored separately, as exemplars. Both models have received some experimental support (e.g., Byatt & Rhodes, 1998; Valentine & Endo, 1992). Recent studies have shown that gender can be considered being one dimension in face-space as ratings of face distinctiveness is evaluated in relation to gender-specific prototypes (Baudouin & Gallay, 2002; 2006).

In summary: Although many face recognition phenomena correspond to findings reported in general memory paradigms, mounting evidence concerning face processing and face recognition has shown that face-stimuli can be considered somewhat special in comparison to other visual stimuli. Optimal face processing is dependent on access to configural and holistic information. Humans are certainly face experts, but to what extent we develop this ability or come by it innately remains to be further investigated.

4. Own-group bias

A large body of research has demonstrated that people generally are better at remembering individuals belonging to the same group as themselves, than remembering individuals from another group (e.g., Meissner & Brigham, 2001; Sporer, 2001; Slone, Brigham & Meissner, 2000). This own-group bias effect, sometimes labeled *out-group homogeneity* effect or *cross-group deficit*, is well documented. The own-bias effect has been found for such characteristics as age, attractiveness, race, and gender (e.g., Fulton & Bartlett, 1991; Lewin & Herlitz, 2002; Lindholm, 2005; Rodin, 1987; Shepherd & Deregowski, 1981; Wright & Sladden, 2003; Wright & Stroud, 2002). However, the explanations for the effects are still under debate.

4.1. Own-race bias

Research on own-race bias, that is, the ability to remember faces from one's own race with higher proficiency than faces from another race-group, has been demonstrated both for ethnic groups of different nationalities and for different ethnic groups of the same nationality (e.g., Brigham & Malpass, 1985; Cross, Cross & Daly, 1971; Wright, Boyd & Tredoux, 2003). For example, studies have shown that Caucasian participants more accurately recognize Caucasian faces and that they recognized Asian faces with less proficiency (Tanaka, Kiefer & Bukach, 2004). The own-race bias has also been found in children (Corenblum & Meissner, 2006; Pezdek, Blandon-Gitlin & Moore, 2003; Sangrigoli, Pallier, Argenti, Ventureyra & de Schonen, 2005) and as early as in three-month-old infants (Bar-Haim, Ziv, Lamy & Hodes, 2006; Sangrigoli & De Schonen, 2004).

Fewer studies have investigated a *cross-over* own-race effect. In order to fully investigate the own-race bias, faces of at least two ethnic groups and two groups of participants with concordant ethnic origin must be part of the study (i.e., a cross-over design) (Sporer, 2001). Results from such studies have rendered somewhat less clear data patterns. Some studies have found the effect, whereas others have demonstrated only partial effects in which Caucasian faces were better remembered by both Caucasians and Afro-American participants (e.g., Chiroro & Valentine, 1995; Cross et al., 1971). One reason for these conflicting results could be that few studies have controlled for distinctiveness in the different face stimuli sets, which could result in unequal memorability for the sets of faces (see e.g., Sporer, 2001).

4.2. Contact and exposure

Meta-analyses have concluded that the causes of and mechanisms underlying the own-race bias, are not fully understood (e.g., Meissner & Brigham, 2001), although many studies have provided evidence for the "contact hypothesis". This hypothesis states that differences in visual experience, depending on degree of exposure and contact between people, result in different knowledge (i.e., expertise) of own versus other-race faces. Several studies have shown that the degree of contact (i.e., the amount of exposure) to out-group faces is related to recognition performance for the other-race's faces (e.g., Chance, Goldstein & McBride, 1975; Wright et al., 2003). Moreover, the idea that exposure elict higher expertise for faces was demonstrated in a recent study where own-race faces were processed more holistically than other-race faces (Michel, Rossion, Han, Chung & Caldara, 2006). However whether it is the amount of contact (i.e., quantity of contact) or the quality of contact that is important is unclear. In a meta-analysis, the amount of self-rated contact with other-race individuals accounted for only 2% of the variance in recognition of other-race faces (Meissner & Brigham, 2001). Moreover, although there is no evidence for a direct link between (racial) attitudes and the own-race effect, there is a significant mediating link between the amount of contact and racial attitude. People with a more positive racial attitude report having greater contact with individuals with another racial background (Meissner & Brigham, 2001).

As alluded to in section 3.3, Valentine (1991) proposed a model for how faces are represented in memory. The more extensive exposure to own versus other-race faces is assumed to result in a face-norm primarily based on own-race faces. The face-norm is therefore more appropriate for encoding of same-race than other-race faces. Thus, other-race faces are represented further out on the axes of the multidimensional face-space because they differ from own-race faces. In addition, as other-race faces are not encoded equally well, they are represented closer together in face-space. The clustering of own versus other race faces was demonstrated in a neural network simulation (Caldara & Abdi, 2006). The clustering of other versus own-race faces in face-space makes the discrimination between them more difficult, and poorer representation of other-race faces leads to deficits in face recognition performance.

Others have suggested that the features, which are informative when it comes to discriminating and remembering own-race faces, may not be equally applicable when encoding other-race faces. At encoding of other-race faces, attention may be directed to facial properties that are useful for discriminating between own-race faces. However, these properties, such as skin color, may be less than optimal for discriminating faces from the other-race, thus leading to poorer memory performance of other-race faces (Gibson, 1969; Meissner & Brigham, 2001).

4.3. Attention and cognitive disregard

Another line of research has argued that the own-group bias can be a result of the amount of attention paid to own- versus other-group faces. The lack of interest in and attention to out-group members can work as a form of cognitive disregard (Rodin, 1987). Out-group members' faces may be less attended to and may also solely be attended to at a categorical level. More attention to own-group faces than to out-group faces can lead to higher recognition performance for own-group faces. When faces are categorized as out-group faces, and are less self-relevant, less effort may be spent on processing these faces in depth and in an elaborate manner. This, in turn, may lead to face recognition deficits for out-group faces (Sporer, 2001). This line of reasoning was supported by results in experiments where individuals who showed more rapid other-race categorization also showed a higher degree of own-race bias (Levin, 2000). It was also revealed that other-race faces were classified faster than own-race faces (Levin, 1996) and that the classification of other-race faces were faster when the other-race cues were made more salient (Levin & Angelone, 2001). Levin (2001) also argued that other-race faces are generally attended to at a categorical rather than at an individual level.

In summary**:** A large body of evidence suggests that the own-race bias is a robust effect that is partly determined by people's visual experience. However, so far the data have not well been able to explain what type of experience (i.e., quantity and/or quality) is needed for the own-race bias to appear, or how the cognitive mechanisms underlying the effect operate.

5. Sex differences in cognitive abilities

Since Maccoby and Jacklin (1974) conducted their meta-analysis of psychological sex differences, there has been a spurt of research on sex differences in cognitive psychology. Although there are no general sex differences in overall IQ scores, it is by now widely accepted that some cognitive differences do exist (e.g., Hyde & Linn, 1988; Voyer, Voyer & Bryden, 1995). Below follows three sections on cognitive abilities where sex differences have been reported. Although not an exhaustive review of the cognitive abilities in which sex differences are found, select tasks measuring the reviewed abilities were included in Study I-III.

Within research on sex differences, the size of the difference is often evaluated and described using Cohen's *d* (Cohen, 1988). Cohen's *d* is a standardized measure of the degree of disparity between two groups' mean values. The *d*-value is calculated by taking the mean for one group (e.g., women) minus the mean for the other group (e.g., men), divided by the pooled standard deviation. According to Cohen (1988), $d = 0.20$ reflects a small difference, $d = 0.50$ a medium difference and a $d = 0.80$ or above is considered a large difference.

5.1. Spatial abilities

Although not a unitary construct, spatial ability is believed to measure the ability to carry out mental manipulations of spatial relations (Colman, 2003; Linn & Petersen, 1986). Two common tasks used to measure visuospatial abilities are (1) matching of identical block figures, which are differentially rotated in space (i.e., mental rotation task), and (2) spatial perception, where the ability to disregard contextual and spatial information embedded in the background is tested (Halpern, 2000; Voyer et al., 1995). Across age and cultures, men outperform women in a range of spatial tasks reflecting that sex differences in spatial abilities are reliable and robust (e.g., Astur, Ortiz & Sutherland, 1998; de Frias, Nilsson & Herlitz, 2006; Herlitz & Kabir, 2006; Thilers, MacDonald & Herlitz, 2006). Levine, Huttenlocher, Taylor & Langrock (1999) showed that boys as young as four and a half years generally performed at a higher level than same-age girls in spatial tasks. In a meta-analysis, Voyer et al., (1995) showed that reliable sex differences for mental rotation tasks were present across all age ranges (d = 0.56).

5.2. Verbal abilities

As for spatial abilities, verbal abilities are not a unitary construct but can be divided into a range of different competencies, where different aspects of language are needed to perform the tasks (e.g., Hyde & Linn, 1988). A large body of research has shown that women outperform men on a range of verbal tasks such as speech production (i.e., the ability to generate as many words as possible beginning with a specific letter during a finite amount of time) (e.g., Herlitz, Airaksinen & Nordström, 1999; Hyde & Lynn, 1988) and verbal association (Hines, 1990). In a meta-analysis, small but reliable sex differences favoring women in verbal abilities were reported (Hyde & Linn, 1988) across verbal tasks, Cohen's d = 0.11. However, some verbal tasks, such as completing analogies, showed a male advantage. Semantic verbal tasks, such as including matching of word synonyms (i.e., general knowledge), generally show no sex differences (e.g., Lewin & Herlitz, 2002). In comparison to spatial abilities, sex differences in speech production are somewhat smaller. However, several recent large-scale studies have found that the female advantage in speech production is stable across age and present in samples of both children, adults, and elderly (de Frias et al., 2006; Gerstrof, Herlitz & Smith, 2006; Strand, Deary & Smith, 2006).

5.3. Episodic memory

In keeping with the findings above, in which sex differences are found to favor women in verbal and men in spatial abilities, a similar pattern of sex differences can be found on tasks assessing episodic memory. In a study by Herlitz et al., (1997), women performed at a higher level than men on all verbal episodic memory tasks and a face recognition task. Others have reported similar results (e.g., Lewin, Wolgers & Herlitz, 2001; McGivern et al., 1997). Somewhat conflicting findings are reported for object recognition of nameable and abstract pictures, showing both female and male advantage, or no sex differences (Cherney & Ryalls, 1999; Goldstein & Chance, 1970; Lewin et al., 2001; McGivern et al., 1997; 1998; Postma et al., 2004). The conflicting results can reflect sex differences in interest and prior knowledge of the items included in the memory task (see, e.g., McKelvie, Standing, St. Jean & Law, 1993; McGivern et al., 1997). For example, when episodic memory required spatial processing, men were found to outperform women (Lewin et al., 2001) However in spatial tasks measuring the ability to memorize the position (i.e., object location) of earlier viewed objects some studies have reported a female advantage and others report no sex differences (Postma, Jager, Kessels, Koppeschaar & van Honk, 2004; Silverman & Eals, 1992). Hence, the pattern of sex differences in episodic memory varies as a function of the type of task under investigation. Whether this pattern is an effect of the earlier described general advantages that men and women show in spatial and verbal abilities, respectively, or whether there is a general episodic memory advantage favoring women as suggested by Herlitz et al., (1997) requires further investigation.

In summary: The findings of sex differences in cognitive abilities, especially spatial and verbal ability, have shown sufficient consistency across a range of studies to allow us to conclude that men generally are more proficient than women in spatial skills and that women generally excel in verbal skills. Episodic memory tasks requiring either spatial or verbal processing have shown similar patterns of sex differences.

5.4. Explaining sex differences in cognitive abilities

The causes of sex differences in cognitive abilities are not fully understood. The majority of theories attempting to explain cognitive sex differences can be divided into two major viewpoints: whether cognitive sex differences are assumed to be driven by biological differences or whether they are a result of the way men and women are shaped by experiences over the course of a lifetime (i.e., psychosocial theories).

5.4.1. Biological theories

Halpern (2000, *p.* 137) have described three different paths researchers have taken in elucidating sex differences using biological theories. These are by necessity intertwined within people, but can grossly be divided into the study and impact of genes and (sex) chromosomes, hormones, and differences in the neuro-anatomical structure and function of the brain. Currently, there is no evidence for a direct link between genes or sex chromosomes and sex differences in cognition. This might reflect the difficulty of knowing which genes to search for and the nature of their direct link to cognitive ability. Moreover, both gene-gene and gene-environmental interactions cloud the search for a link between genes and cognition. There is, of course, an indirect link between x versus y (i.e., the sex-linked chromosomes).

Sex differences have generally been found in spatial and verbal abilities, which might have led researchers to examine the associations between these differences and the degree of laterality in the brains of men and women. One theory argues that spatial performance is more optimal when there is a high degree of localization of the spatial function within the right brain hemisphere (Levy, 1971). The greater bilateral representation of language in both hemispheres is thought to disrupt optimal processing of spatial material, but to result in a greater ability to process verbal material (Levy, 1971). Research has shown that brain lateralization (e.g., the notion that there is functional specialization of the two cerebral hemispheres and that spatial and verbal abilities have different locations in the brain) is more pronounced in men than in women (Voyer, 1996). In support of this, a more bilateral pattern in the visual and auditory functions was found in women than in men. This reasoning has been supported in a functional magnetic imaging study (Vikingstad, George, Johnson & Cao, 2000; but see also Frost et al., 1999).

In rodents, hormones have a crucial impact on the developing fetal brain. During gestation and throughout life, female and male fetuses are exposed to both estrogen (i.e., usually labeled the female hormone) and testosterone (i.e., usually labeled the male hormone). Although both men and women are exposed to both estrogen and testosterone, the levels greatly differ between males and females. In humans, there is evidence for an association between fetal levels of androgens and later behavior (for a review see Cohen-Bendahan, van de Beek & Berenbaum, 2005). For example, girls who were exposed to higher than normal doses of androgens due to an enzymatic defect (congenital adrenal hyperplasia, CAH) displayed greater activity in so-called rough and tumble play and played less with dolls (Berenbaum & Hines, 1992; Servin, Bohlin & Berlin, 1999). There is also evidence showing that brain lateralization is associated with prenatal testosterone levels in both boys and girls (Grimshaw, Bryden & Finegan, 1995). This was interpreted as supporting the hypothesis that higher androgen levels are associated with greater degree of brain lateralization. However, studies on the effect of early hormonal exposure and its relation to cognition are scarce in humans and have not provided us with unambiguous results (see Cohen-Bendahan et al., 2005).

Another way to conceptually investigate different explanations for the displayed sex differences has been to study the stability of these differences across cultures and ages. Finding similar result patterns across different countries with different cultural settings and finding stable sex differences across the lifetime have been argued to indicate that the displayed differences may be based on biological differences (see, e.g., Geary, 1999). Others have taken a similar view when stable early sex differences for "less stereotyped" abilities such as perceptual knowledge (e.g., fine discrimination between odors or sounds) have been reported (Halpern, 2000).

5.4.2. Psychosocial theories

Throughout the lifespan, men and women are exposed to and shaped by different environmental pressures. Theories with a social constructionist perspective have therefore adopted the view that men and women differ not because they are innately different, but because men and women construct environments that shape them differently (e.g., Lorber, 1994). Research within this paradigm has roots in both cognitive (e.g., Bem, 1981a), and social learning theories (Bandura & Walters, 1963). Other researchers have argued that men and women differ with respect to what is valued to, and expected of, them (e.g., Eccles, 1994; Wood & Eagly, 2002; for an overview see Halpern, 2000).

The process of socialization, whereby shaping of appropriate sex-roles and what is expected from men and women takes place, starts as soon as the infant is born. Already in infancy, differences between how females and males are treated are detected. For example, adults talk and express themselves differently when they speak about boys and girls (Culp, Cook & Housley, 1983), and assertiveness is encouraged in boys but not in girls (Fagot, 1974). In school, girls are expected to be more organized and structured (Gough, 1998), and as adults, women are generally expected to do more social shores than men, such as taking care of children and the household (Deaux & Major, 1987).

Bem's (1974; 1981a) gender-schema theory states that both men and women construct their gender schema by learning the societal expectancies for men and women. The cognitive schema, which encompasses the structure and knowledge of appropriate femaleness and maleness, can act as a filter or as perceptual readiness to process information in concordance with the person's own gender schema. Men and women with a gender schema in concordance with their biological sex are considered *sex-typed*. However, both men and women can also ascribe themselves high and low values for female and male attributes (i.e., being *cross-sex typed*), resulting in different gender schemata independent of their biological sex. Thus, cross-sex typed individuals are also sex-typed in that they have a readiness to organize information on the basis of gender. Studies have shown that people who are sex-typed to a higher degree than *non-sex-typed* people remember information clustered together according to its' feminine or masculine association (Bem, 1981b). In line with Bem's gender-schema theory, studies have shown the impact of gender stereotypes on, for example, memory performance. Individuals more accurately remember material that is consistent with their sex-role stereotype (Cann & Newbern, 1984; Signorella & Liben, 1984).

One principal idea of the psychosocial theories is to demonstrate and explain how cognitive sex differences can depend on practice. In line with this, a reliable association between the amount of computer use and performance on spatial tasks is found independent of sex (Terlecki & Newcombe, 2005). Studies have also shown that spatial ability is trainable and can improve (Baenninger & Newcombe, 1989; DeLisi & Cammarano, 1996). However, studies typically show that men and women improve equally, resulting in maintained sex differences.

In Summary*:* Evidently, biological theories can not be reduced to a matter of heredity, as experience is known to model the brain (Draganski, Gaser, Busch, Schuierer, Bogdahn & May, 2004). Although both biological and psychosocial theories have received empirical support, it is important to acknowledge that these two views on the origin of sex differences are not mutually exclusive, neither within the individual, nor within society. As mentioned in the introduction, the current thesis adopts the psychobiosocial perspective, assuming that biological and psychosocial environments are dynamically interactive systems and that both views are necessary for understanding cognitive sex differences (Halpern, 2000).

6. The role of gender in face recognition

A great deal of research has shown that humans show a recognition bias for same-race faces (e.g., Sporer, 2001). In contrast, own-sex bias and sex differences in face recognition have not received much attention.

6.1. Sex differences in face recognition

Although few studies have directly set out to measure sex differences in face recognition, evidence of such differences has been reported. Females, spanning a wide age range, have been found to recognize more faces than males do (de Frias et al., 2006; Herlitz et al., 1997; Schretlen, Pearlson, Anthony & Yates, 2005; Shapiro & Penrod, 1986; Yarmey, 1974; Whalin et al., 1993). Thus, the results seem to indicate that there are performance differences in face recognition that are related to gender. However, these studies all share one important disadvantage: they have not studied the effect of recognition performance for female and male faces separately. Therefore, sex differences for female and male faces, and own-sex biases have not been evaluated in these studies, thus, studies directly investigating the own-sex bias effect are few.

Depending on whether sex differences for faces or sex differences for both female and male faces were evaluated separately, the explanations have differed somewhat. Studies showing that females generally recognize more faces than men have explained the effects in terms of a general sex difference framework, arguing that the female advantage in face recognition may be a result of women's general verbal advantage. However, a direct investigation of the verbal mediating effect found no support for such a hypothesis (Lewin & Herlitz, 2002). McKelvie and colleagues (1993) showed that women outperformed men in recognition of children and that men outperformed women in recognition of cars. They suggested that women are better at recognizing children because women are generally more interested in children. Accordingly, women would have greater interest in people than men do, resulting in greater face recognition performance.

The hypothetical Figures 2-5 represent an attempt to schematically present previous results on sex differences in face recognition. The schematic presentations are a simplistic representation of data, but should illustrate that different explanations may be needed to explain the patterns of sex differences in face recognition on the one hand, and the pattern of own-sex biases on the other. For example, the evidence of sex differences in face recognition presented earlier in this section could be displayed as in Figure *2*. Evidently, no information regarding sex differences for female and male faces can be evaluated.

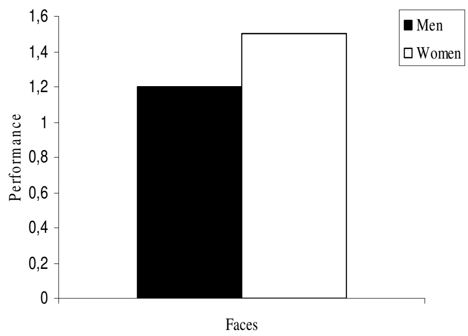

Figure 2.

6.2. Sex differences for female and male faces

As reported earlier, the pattern of sex differences in episodic memory can be influenced by the material (Lewin et al., 2001; McGivern et al., 1997). Although earlier research is sparse, studies taking the gender of faces into account have revealed that females more accurately recognize females' faces than men do. No studies reporting a male advantage in recognizing female faces have been found (Cross et al., 1971; Ellis, Shepherd & Bruce, 1973; Feinman & Entwisle, 1976; Going & Read, 1974; Lewin & Herlitz, 2002; McKelvie, 1981; McKelvie, 1987; McKelvie et al., 1993; Vokey & Read, 1988; Wright & Sladden, 2003; Yarmey, 1974).

In contrast, sex differences for male faces are less straightforward. Some studies report sex differences favoring females, some no sex differences, and yet others have found that males outperform females in the recognition of male faces (e.g., Ellis et al., 1973; Feinman & Entwisle, 1976; Lewin & Herlitz, 2002; McKelvie, 1981; 1993; Wright & Sladden 2003). Thus, the overall pattern of sex differences in face recognition studies may be displayed as in Figure 3.

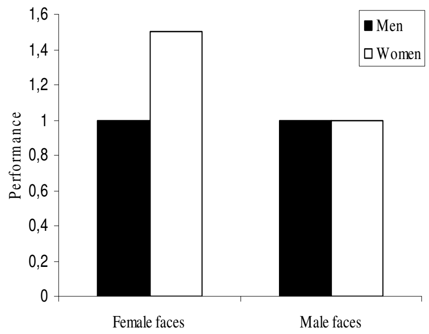

Figure 3.

6.3. Own-sex bias

Importantly, sex differences and own-sex biases are distinct and can be present independently of the other. An own-sex bias would be present if men and women were significantly better at remembering same-sex faces than opposite sex-faces. For example, men could be more proficient at recognizing male faces than female faces, without the presence of any sex differences for male faces (see Figure 4).

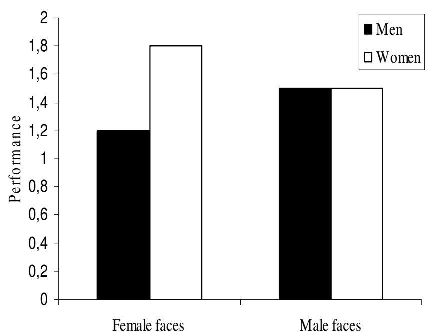

Figure 4.

The evidence so far reveals that women show an own-sex bias, that is, they recognize more female than male faces (e.g., Feinman & Entwisle, 1976; Lewin & Herlitz, 2002; Wright & Sladden, 2003; but see also McKelvie, 1981, 1987; McKelvie et al., 1993). In contrast, men generally do not show an own-sex bias. Instead, some studies show that men remember female and male faces equally well (e.g., Cross et al., 1971; Going & Read, 1974; Lewin

& Herlitz, 2002) or that men, just like women, recognize more female faces (Feinman & Entwisle, 1976; McKelvie et al., 1993). Few studies have shown a male own-sex bias (Feinman & Entwisle, 1976; Wright & Sladden, 2003). Thus, another possible representation of previous results is displayed in Figure 5.

Evidently, several issues are unclear, both in terms of sex differences and in terms of own-sex biases, and therefore need further investigation. It is, for example, not known whether the female own-sex bias is present when girls view female faces of different ages and of different ethnicities, or when women view female faces of different ethnicities. Further, prior studies on sex differences in face recognition have not investigated if and to what extent degree of familiarity of faces, influence sex differences. This is important to investigate in order to determine how general sex differences in face recognition are. Thus it is not well know what the general pattern of sex difference across female and male faces look like and if it can be represented as in Figures 3, 4 or 5.

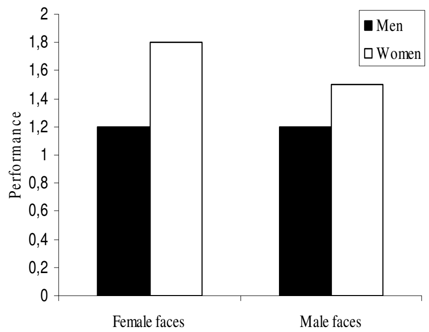

Figure 5.

With regard to explanations of the female own-sex bias, it has been suggested that it is found because females pay more attention to other females (e.g., Cross et al., 19971; McKelvie, 1981), especially attractive and familiar female faces (i.e., of the same age and ethnicity). Support for this explanation is weak (see, e.g., McKelvie 1981), and new evidence has shown that both attractive and less attractive faces can be distinct in terms of their memorability (Morris & Wickham, 2003). Further, in a study where both men and women displayed own-sex biases, hair was shown to be an important factor contributing to the bias, possibly reflecting the fact that hair can act as a gender cue (Wright & Sladden, 2003). Finally, it has been speculated that women may have better knowledge of female faces due to their exposure to female faces in, for example in magazines (e.g., Ellis, 1975), a hypothesis that draws on the “contact hypothesis”. This hypothesis has not been explored. Little attention has been paid to the explanations suggested in research on other own-group biases. Thus, not much is known about why women show a female own-sex bias and why there seem to be sex differences in the display of own-sex bias.

In summary**:** Research on sex differences in face recognition is sparse and has not always taken into account possible performance differences for female and male faces separately. Females are generally reported to remember more faces than males do, and females are particularly able to remember other females’ faces. However, the generality of the pattern of sex differences across male and female faces, and explanations for sex differences and own-sex biases are largely unknown.

7. Aims and summaries of the three empirical studies

The aims of the present thesis were based on findings from earlier studies reporting sex differences in face recognition and evidence of own-sex bias (e.g., Ellis et al., 1973; Lewin & Herlitz, 2002; McKelvie, 1981).

The first aim was to investigate the generality of the female own-sex bias. This was assessed in Study I and Study II by studying girls' and women's face recognition performance for young and adult female faces of Bangladeshi and Swedish origin.

The second aim was to investigate the generality of sex differences in face recognition for female and male faces. This was done in Studies I and II by examining sex differences in the recognition of female and male faces from two different age and ethnic groups. The generality of sex differences in face recognition was further examined in Study III by investigating sex differences in face recognition of androgynous (i.e., non-gender-specific) faces.

The third aim was to examine possible explanation(s) for sex differences in face recognition. In Study I, face recognition was evaluated in relation to men's and women's gender schemata. In Study III, mechanisms of the own-sex bias were investigated by studying men and women's face recognition performance for androgynous faces labeled either "men" or "women".

7.1. Methodology

The three studies included in this thesis were conducted within a cognitive psychology paradigm, using quasi-experimental designs.

7.1.1. Measures

A typical method for investigation of face recognition was employed in the three studies (see e.g., Rakover & Cahlon, 2001). Faces were presented in sequence and were after a time interval (ranging between 7 and 14 minutes) presented again randomly intermixed with a set of new, earlier nonpresented faces. Face recognition accuracy was the dependent variable in Study I, II and III. Study II also included measures for *hits* (i.e., correctly recognized faces) and *false alarms* (i.e., mistakenly recognizing a new stimulus as old) in order to evaluate these effects separately.

In addition to the face recognition tasks, Study I, II and III assessed performance on a range of other cognitive tasks. These tasks acted as filler tasks which participants completed between presentation and the recognition of faces. As all studies investigating gender differences are correlational or quasi-experimental by nature, these tasks were therefore also used to evaluate patterns of expected similarities and differences in cognitive abilities (e.g., Herlitz et al., 1997; Voyer et al., 1995). Furthermore, performance on these tasks was also used to evaluate cognitive similarities and differences across groups of participants included in different conditions (Study I, II and III).

A test of *mental rotation* was included in all three studies. The task was a revised (I and III) and simplified (Study II) version, encompassing 10 target figures of the Shepard-Metzler Mental Rotation Test for group administration (Vandenberg, 1971). The dependent measure for this task was number of correctly marked figures (Study II), corrected for guessing (Study I and III).

One *word comprehension* task for adults (Study I and III; Nilsson, Bäckman, Erngrund & Nyberg et al., 1997) and one for children (Study II; Järpsten & Taube, 1997) was included. Participants were asked to indicate the target words' correct synonym. Dependent variable was number of correctly marked synonyms.

A *verbal episodic memory* task, administered as the face recognition tasks, was included in Study I and II. Accuracy scores on this task were calculated as the number of *Hits* minus *False Alarms*. In addition, a measure of *verbal fluency*, letters S and A, and a modified *perceptual speed task* (Bartfai, Nyman & Stegman, 1992; Wechsler, 1981) was included in Study III. In the verbal fluency task, participants were asked to generate and write down as many words as possible during one minute, starting with a given letter. In the perceptual speed task, the number of digits to figure completions constituted the dependent variable.

Finally, in Study I, a short form of *Bem Sex Role Inventory* was used to assess the participants' gender schema (Bem, 1981a). The inventory consists of 30 adjectives, 10 classified as feminine (e.g., affectionate), 10 masculine (e.g., aggressive) and 10 gender neutral (e.g., conventional). The participants are asked to indicate, on a seven-point scale, how well the adjectives describe her or him. The gender schema classification is based on a median-split, so that for example a person scoring lower than the median on adjectives classified as feminine and above the median on adjectives classified as male, are considered to have a masculine gender schema.

7.2. Study I: Women remember more faces than men do.

Although some studies have investigated sex differences in face recognition in adults, none have jointly studied sex differences in face recognition for female and male faces of different ethnicities and ages (see also McKelvie, 1981, 1987). The aims of Study I were to investigate the generality of sex differences and of the female own-sex bias in face recognition. Of particular interest was whether women would display a female own-sex bias for girls' faces. Sex differences in face recognition were previously explained as being a result of women's interest in people, resulting in enhanced face recognition performance (e.g., McKelvie, 1981). Moreover, Bem (1981b) argued that people who are sex-typed would remember more information in accordance with their gender schema. Assuming that interest in other people is associated with a female gender schema, the third aim was to investigate whether both men and women classified as having a female gender schema would show enhanced face recognition performance in comparison to same-sex participants with a male gender schema.

One hundred and seven men and 112 women (mean age = 30.2, *SD* = 5.6) took part in the study. All men and women completed two face recognition tasks, comprising either Swedish or Bangladeshi faces (50% female, 50% male faces). The two sets of faces consisted of child or adult faces. A short version of the Bem sex role inventory was included to assess participants' gender schema (Bem, 1981a). Participants also completed a set of cognitive tasks in order to statistically control for potential cognitive differences between men and women and participants viewing Bangladeshi or Swedish faces.

The results showed that women recognized more faces of girls and women than faces of boys and men, independent of whether the recognized faces were of Bangladeshi or Swedish origin, thus showing a reliable own-sex bias. For men, a similar pattern of results was found; they also remembered girls and women more accurately than they remembered boys and men (see Figure 6). Hence, men displayed no own-sex bias. Further, the results indicated that women recognized more Bangladeshi and Swedish females than men did and more male faces when data were collapsed across male faces.

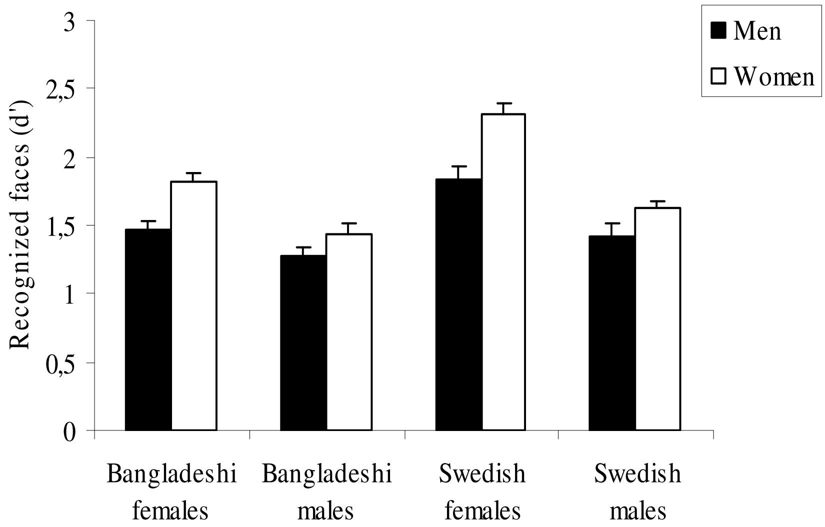

Figure 6. Mean number of recognized (with standard error bars) Bangladeshi and Swedish female and male faces for men and women, respectively.

These results were discussed in relation to men's and women's possible differential interest in and attention directed towards other individuals. More specifically, it was suggested that the female own-sex bias is present because women's interest is particularly directed towards other females, which has been suggested earlier (e.g., Ellis, 1975). Analysis of the sex role inventory (Bem, 1981a) in relation to face recognition showed a weak, non-significant tendency for individuals displaying a female gender schema to outperform individuals with a masculine gender schema. Divided by sex of participants, no differences were found between men with a female gender schema and men with a masculine gender schema, whereas a weak, non-significant effect was found for women.

Conclusions from Study I: The study replicated and extended findings from earlier studies by showing that the female own sex-bias is present when women remember girls' faces, and for ethnically familiar and unfamiliar female faces. For men, no own-sex bias was found. Moreover, the presence of a general female advantage in face recognition was apparent, although the advantage was weaker for male than for female faces. The notion that there is a relation between gender schema and face recognition performance was not supported.

7.3. Study II: Higher face recognition ability in girls: Magnified by own-sex and own-ethnicity bias

Earlier studies have shown that women and girls are more accurate at recognizing female than male faces (e.g., Study I; Lewin & Herlitz, 2002; McKelvie, 1987). However, studies examining the female own-sex bias in children have reported conflicting results (Ellis et al., 1973; Cross et al., 1971; Feinman & Entwisle, 1976). Thus, the aims of Study II were to examine sex differences for female and male faces in children and to investigate the stability of the female own-sex bias across female faces of different ages and ethnicities. It was hypothesized that the degree of familiarity, that is, the concordance between the participant and the face to be remembered, would affect recognition performance. Hence, larger female sex differences were expected to be found for faces in concordance with Swedish girls (i.e., faces of Swedish girls), whereas less or no sex differences were expected for Swedish male faces. Further, we expected girls to show a stable own-sex bias and boys a lack thereof.

Altogether 88 boys and 109 girls with a mean age of 9.3 (*SD* = .32) years took part in the study. The testing took place during school hours in the children's classrooms. A collection of cognitive tasks was included to enable statistical control for cognitive differences between the groups of participants. The children completed two different face recognition tasks, one comprising children's faces (i.e., boys and girls) and one comprising adult faces (i.e., men and women). Approximately half of the participants completed face recognition tasks with Bangladeshi faces and the other children ($n = 101$) were tested with Swedish faces.

Consistent with previous findings (e.g., Ellis et al., 1973), the results revealed that girls remembered more faces than boys did. This was qualified by an interaction between sex of the child and gender of faces, showing that girls recognized more female faces than boys did but that the difference was not statistically significant for male faces. Further, the sex difference was unreliable for Bangladeshi male faces, where girls tended to recognize more male faces than boys ($p = 0.10$) (see Figure 7). These results were discussed in terms of a general female face recognition advantage and in terms of differences in interest in faces (e.g., McGivern et al., 1997; McKelvie et al., 1993). The size of the sex difference for female and male faces was argued to reflect the degree of concordance between the recognized faces and the individual. Girls showed consistent own-sex bias for all female faces, whereas boys showed no reliable own-sex bias. These results replicate and extend earlier findings (e.g., Lewin & Herlitz, 2002) on girls' own-sex bias and boys' lack thereof.

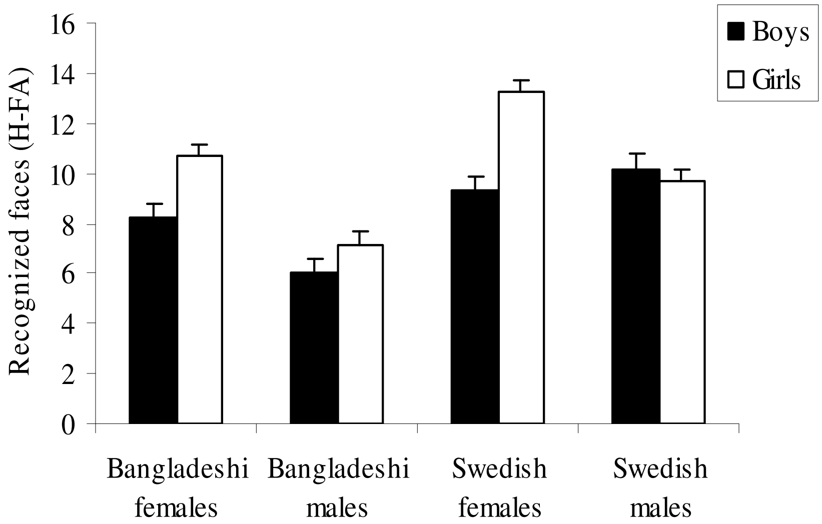

Figure 7. Mean number of recognized (with standard error bars) Bangladeshi and Swedish female and male faces for boys and girls, respectively.

***Conclusions from Study II*:** Study II showed that the female own-sex bias is substantial and reliable even during more constrained and difficult face recognition conditions, such as in the recognition of Bangladeshi females. Moreover, the girls showed a tendency towards an overall face recognition advantage over boys. Boys recognized Swedish male faces as accurately as the girls did, but remembered fewer Bangladeshi male faces than the girls did.

7.4. Study III: Why women remember women – Gender labeling of androgynous faces produces a female own-sex bias

Explanations for the female own-sex bias have largely been unexplored. It has been suggested that the female own-sex bias could be a reflection of greater interest in and attention paid to other females, resulting in enhanced recognition ability for female faces (e.g., McKelvie, 1981; Ellis, 1975). However, others have speculated that the female own-sex bias might arise from women's greater knowledge of female faces (e.g., Ellis et al., 1973).

Thus, the first aim of Study III was to investigate whether women would exhibit an own-sex bias for faces independent of the prior knowledge (i.e., expertise) that women may have of female faces. Therefore, the same androgynous faces (i.e., non-gender specific faces) were presented and labeled as either "men" or "women". After a retention interval, the participant's face recognition performance for the androgynous face was tested. A second aim was to investigate whether sex differences in face recognition are general (e.g., Hill et al., 1995; Yonker, Eriksson, Nilsson & Herlitz, 2003) and not only a result of women's advantage for female faces. This was studied by evaluating men's and women's face recognition performance for androgynous faces.

One hundred and twenty-three men and 161 women, with a mean age of 17.86 (*SD* = .62) took part in the study. Participants completed one of three face recognition tasks. Androgynous faces were all created from men's and women's faces using Morpheus™ software. The androgynous faces were labeled "men", "women", or "faces", prior to presentation. The androgynous faces were intermixed with additional morphed faces depicting men, women, or additional androgynous faces, depending on the condition.

The results showed that women remembered more faces than men did in all three face recognition conditions; hence women remembered more androgynous faces in addition to remembering more faces in the condition where faces were labeled "men" and "women". These results were believed to support the notion of a general female face recognition advantage, which is suggested to reflect differences in female and males' orientation towards other individuals.

Second, women who were told to remember women, accurately recognized more androgynous faces than did women who were told to remember "men" or non-gender-specific faces (see Figure 8). This finding was believed to reflect that women's attention is directed more towards faces believed to portray females, resulting in enhanced recognition performance for these faces. Thus, the female own-sex bias is not thought to reflect that women have greater expertise for female faces. Men's face recognition performance did not significantly differ across the three experimental conditions. Again, no evidence of a male own-sex bias was found.

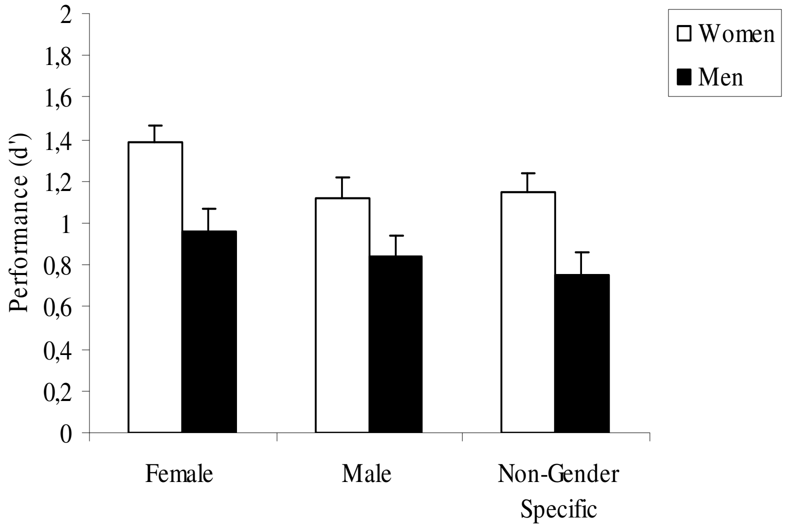

Figure 8. Mean number of recognized faces (with standard error bars) in the three conditions (female, male, and non-gender specific), for men and women, respectively.

Conclusions from Study III: Women do not outperform men in face recognition tasks exclusively because of an elevated recognition performance for female faces. Instead, women show a general face recognition advantage. Moreover, women's own-sex bias and men's lack thereof are thought to reflect differences in the attention directed towards own-sex faces. Women attend more to other faces perceived as females, resulting in greater recognition performance. Men may attend less to faces in general, in comparison to women, but do not seem to differentiate between the amount of attention paid to female and male faces, resulting in a lack of own-sex bias.

8. General discussion

In the subsequent sections, the main findings of this thesis will be discussed in relation to past and more recent research. The current results will also be evaluated with regard to some possible limitations, and suggestions for future research on sex differences in face recognition will be made. The thesis will end with a summary and some concluding remarks.

8.1. The female own-sex bias

The first aim of the current thesis was to investigate the generality of the female own-sex bias. This was assessed in Study I and Study II by studying girls' and women's face recognition performance for young and adult female faces of Bangladeshi and Swedish origin. Although a few earlier studies have found support for the presence of a female own-sex bias, evidence was lacking regarding the generality of the findings (e.g., Cross et al., 1971; Feinman & Entwisle, 1976). Results from Study I and Study II consistently show that both girls and women are significantly better at remembering female faces than male faces, irrespective of the age and ethnicity of the faces to be remembered. Hence, Swedish girls and women remembered more Bangladeshi girls and women than Bangladeshi boys and men. Girls and women also more accurately remembered Swedish girls and women than they recognized Swedish boys and men. This data pattern was consistent with the majority of the earlier findings (e.g., Lewin & Herlitz, 2002; Wright & Sladden, 2003). Interestingly, the female own-sex bias is also reliable for unfamiliar faces, such as the Bangladeshi female faces.

In general, the size of the female own-sex bias in Study I and II was large. Across the different female face conditions, the effect in Cohen's, *d,* ranged between 0.74 and 1.24, (see Table 1). A d=1.00 corresponds to an explained variance (r^2) of 20% (Cohen, 1988). Hence, 20% of the variance in women's face recognition ability can be attributed to the own-sex bias. Notably, for girls and women the own-sex bias was generally stronger than the own-race effect (see Table 1). Taken together, the data show that the female own-sex bias is strong and reliable across a range of different female face categories.

Table 1. *Effect Size (d) for the Own-Race Bias for Female and Male Faces and the Own-Sex Bias for Bangladeshi and Swedish Faces. Based on Data From Study I and II (Not Previously Included in Study I and II).*

	Own-Race[1]		Own-Sex[2]	
	Female	Male	Bangladeshi	Swedish
Girls	0.77	0.66	1.02	0.95
Women	0.92	0.43	0.74	1.24
Boys	0.29	1.15	- 0.64	0.21
Men	0.58	0.30	- 0.41	0.57

[1] The effect size (*d*) for own-race = $(M_{own\text{-}race} - M_{other\text{-}race}) / SD_{pooled}$

[2] The effect size (*d*) for own-sex = $(M_{own\text{-}sex} - M_{opposite\text{-}sex}) / SD_{pooled}$

8.2. The male own-sex bias

In contrast to the stable pattern regarding the female own-sex bias, earlier studies have found inconsistent results with regard to the male own-sex bias (e.g., McKelvie et al., 1993; Wrigth & Sladden, 2003). Data from Study I, II and III complement existing data, demonstrating that both boys and men in most instances did not show an own-sex bias, the only exception being that boys recognized more Swedish boys' faces than Swedish girls' faces.

The pattern of inconsistencies can have different causes. One interpretation is that the male own-sex bias exists, but is of lesser magnitude as compared to the female own-sex bias. The weak male own-sex bias may only be present when the concordance between the male viewer and the face to be remembered is high, such as was seen in Study II when young Swedish boys recognized young Swedish boys. In line with the notion that the male own-sex bias only surfaces when the concordance between the viewer and the face to be recognized is high, Wright and Sladden (2003) found a male own-sex bias when the male participants and the male faces were of the same ethnicity and age. The discrepancy between the age of the males portrayed in the pictures and the men participating in the study was somewhat greater in Study I and III. However, in Study I, men's own-sex bias was not stronger for Swedish than for Bangladeshi faces. Therefore, a more likely explanation of the inconsistent findings of a male own-sex bias is that the male own-sex bias is weaker than the female own-sex bias, or even non-existent. In such instances, different patterns both across and within studies should be expected (i.e., type I error).

8.3. Explanations for the reliable female own-sex bias

The third aim of the present thesis was to examine possible explanations for the own-sex bias. Earlier studies have suggested that the female own-sex bias exists because females have greater expertise of female faces (e.g., Ellis et al., 1973). Others have suggested that the female own-sex bias arises because females are particularly interested in and pay more attention to female as compared to male faces (e.g., Cross et al., 1971). More attention directed towards female faces would result in a more proficient recognition performance for female faces (Richardson-Klavehn & Bjork, 1988). Study III showed that women more accurately remembered androgynous faces labeled ”women” than the same androgynous faces labeled “men”. The alternative explanation, that women have greater expertise of female faces, does not explain the findings in Study III, as the same androgynous faces were presented in all three conditions. Instead, we concluded that women recognized more androgynous faces labeled “women” because women pay more attention to faces perceived as females than to faces perceived as males.

8.3.1. Mechanisms

Speculatively, providing the androgynous faces with a female label acted as a cue to direct women’s attention towards these faces. In line with the current results, Wright and Sladden (2003) found greater own-sex biases for faces viewed with than without hair. It is possible that hair acted as a gender cue in the study by Wright and Sladden (2003), directing attention towards same-sex faces. Research on own-race bias has shown that the same faces were recognized to varying degree depending on whether the faces were presented with an Afro-American or a Hispanic racial cue (i.e., specific hairstyles) (MacLin & Malpass, 2001). MacLin and Malpass (2001) concluded that the other-race faces were encoded at a categorical rather than individual level. This is in line with Levin’s (2000) suggested explanation for the own-race effect; out-group faces may be less attended to at an individuating level, leading to poorer recognition performance. Research has also shown that faces are remembered with greater accuracy if participants generate personalized information (e.g., intelligent person), rather than categorize faces according to facial features (e.g., Winograd, 1981), and when the material can be personally related to (Symons & Johnson, 1997). At present, we can only assume that women attended more to the androgynous faces labeled “women”, resulting in higher recognition performance for these faces. However, it is also possible that the label “women” acted as a cue to process the androgynous faces more elaborately, enhancing face recognition performance.

8.3.2. Causes

Why would women pay more attention to, and be more interested in, other females? The effects of the female own-sex bias are substantial and present already at a young age. Nonetheless, it is unlikely that the female own-sex bias stems from a biological preparedness to process or orient themselves specifically towards female faces. Instead the evidence so far suggests that the basis for processing and differentiating between female and male faces is driven by experience of female and male faces. Developmentally, it is known that infants can discriminate between female faces before they can discriminate between male faces (Ramsey, Langlois & Marti, 2005). This is thought to reflect degree of exposure to female and male faces (Quinn, Yahr, Kuhn, Slater & Pascalis, 2002). However, girls already in infancy attend more to faces than boys do (Conellan, Baron-Cohen, Wheelwright, Batki & Ahluwalia, 2000), and infant girls make more eye contact than do infant boys (Lutchmaya, Baron-Cohen & Raggatt, 2002). Therefore, the early exposure to faces, together with the early female preference for orientation towards social stimuli, may start a socialization process whereby females establish expectancy for a special female-to-female reciprocal relationship. This line of argument is also supported in research showing that girls and women have deeper and more face-to-face friendships with other females (Sherman et al., 2000). In line with the psychobiosocial framework, a combination of factors may interact and explain why females show a bias for female faces. This bias might be rooted in early, orientation towards social stimuli, such as seen in the case of toy preference (e.g., Servin, Bohlin & Berlin, 1999), strengthened by interactions with adult women who in turn show greater interest in other individuals and in females in particular.

In summary: Girls and women show strong and consistent own-sex bias across studies. The male own-sex bias is mostly absent. Speculatively, the male own-sex bias can be found when the concordance between the male participant and male face stimuli is high. Females show an own-sex bias because more attention is directed towards faces perceived as females. This may reflect the fact that females are more oriented towards females and, hence, female faces are processed in a more self-referent and elaborative manner, enhancing recognition performance.

8.4. Sex differences in face recognition

The second aim of the present thesis was to investigate the generality of sex differences in face recognition for female and male faces. This was accomplished by presenting faces of different ages, ethnicities, and genders (i.e., male, female, non-gender specific) to samples of children and adults. While sex differences in face recognition are related to the own-sex bias, it is important to stress that they are distinct concepts. Females and males can be equally proficient at face recognition, but show evidence of own-sex biases. However, the current data pattern demonstrates that men and women are not equally proficient at recognizing faces. Instead, and in line with previous research (e.g., Ellis et al., 1973), we found a stable female advantage in the recognition of female faces. Moreover, results from Study I and II indicate that girls and women also outperform men in recognition of male faces, d=0.55 and d=0.48, respectively. However, sex differences were weaker for male than for female faces, and not consistently found (e.g., Study II; McKelvie et al., 1993; Wright & Sladden, 2003). More importantly, results from Study III showed that women outperform men in the recognition of androgynous faces, d=0.39. Hence, it was concluded that sex differences in face recognition are not only a result of women outperforming men in the recognition of female faces.

8.4.1. Explanations for sex differences in face recognition

Explanations are lacking as to why women are more accurate in recognizing faces. In Study I, we investigated the mediating role that gender schema may have in face recognition, as other studies have shown that gender schema can predict memory performance (e.g., Bem, 1981b). Although there was a tendency for women with a female gender schema to remember more faces than women with a masculine gender schema, the same pattern was not seen for men. It was therefore concluded that gender schema, independent of biological sex, does not mediate sex differences in face recognition. However, it is also possible that the inventory did not capture the aspect of "femaleness" and "maleness" relevant to face recognition or that face recognition performance may not be associated with either a female or male gender schema. Future studies should therefore include other personality-related measures that might capture the alleged social interest and orientation, such as interpersonal sensitivity (Hogan & Hogan, 1997), which may, speculatively, influence face recognition performance.

Evidence from a range of different areas can attest to the fact that women generally seem more oriented towards people and social settings than men are. Women more often work in fields where interactions with other persons are necessary (Lippa, 1998), girls' play behavior is more oriented towards dolls than towards mechanical toys (Collaer & Hines, 1995), and girls and women have deeper and more sustained face-to-face friendships, especially with other females (Sherman et al., 2000). Further, girls and women more accurately discriminate between facial emotions than men do (McClure, 2000) and women more accurately remember people's names (Kaess & Witroll, 1955). These findings from other research areas seem to suggest that females and males are oriented towards other people to different degree. Further research is needed before a possible mediating link between social orientation and face recognition can be established. For now, it can only be concluded that people more accurately remember things that they seem to be more interested in or have greater prior knowledge of (e.g., McGivern et al., 1997).

In the present thesis, sex differences showing a female advantage were present both in the sample with nine-year-old children and with adults. Whether sex differences in face recognition have a biological basis remain an open question, as it is still unclear whether face specific processing is innate and predisposed in humans (Turati, Valenza, Leo & Simion, 2005). Thus, future studies need to elucidate the biological origin of face processing in order to further investigate the origin of sex differences in face recognition. Speculatively, sex differences in face recognition might be based on early predispositions concerning general interest and orientation, as seen in infants' looking preferences and in early play behavior (e.g., Connellan et al., 2000; Servin et al., 1999). In addition, other factors such as what is expected of men and women, and what men and women value as being important, can have an impact on what stimuli men and women attend to and value as important (e.g., Eccles, 1994). Early predispositions may be either further established and strengthened, or weakened, throughout life. As suggested by the psychobiosocial perspective, very small biological differences can become larger sex differences through experience and appraisals (Halpern, 2000).

In summary: Sex differences in face recognition are generally found to favor females. The largest and most reliable sex differences are found for female faces. For male faces, sex differences are smaller and less reliable. Speculatively, sex differences in face recognition may have a biological basis, possibly through early predispositions with regard to interests and social orientation, but is enhanced through experience and social learning. However, future studies need to further address whether differences in orientation towards social stimuli can be related to face recognition performance.

8.5. Methodological comments

8.5.1. Validity and generalizability

A standard procedure for measuring face recognition performance was employed in this thesis (see e.g., Rakover & Cahlon, 2001). One important issue is whether the face recognition tasks used here are capable of capturing women and men's everyday ability to remember faces. In general, similar face recognition studies carried out in a laboratory setting have produced valid and replicable results (e.g., Meissner & Brigham, 2001). Moreover, evidence has shown that the own-race effect is found in ecologically valid settings such as in a witness situation (e.g., Brigham, Maass, Snyder & Spaulding, 1982). Therefore it is reasonable to assume that face recognition as measured in the present thesis can be generalized to men's and women's real-life abilities to remember faces. Nevertheless, it is important to further investigate and replicate the findings of sex differences and the female own-sex bias in a more ecologically valid setting.

Participants were self-selected in all three studies. However, the samples were drawn from several settings, with different selection processes, and from populations varying in age, strengthening the generalizability of our findings. Although sex differences have been found in samples with older adult women (de Frias et al., 2006), there are yet no studies investigating a female own-sex bias in older women and in women from non-western countries. Therefore, it would be valuable to replicate Study I and II in for example Bangladesh, and with samples of older men and women, preferably with a population-based sample.

The design of Study III also included a set of morphed faces depicting men, women and androgynous faces. They acted as filler faces and were there to strengthen the notion of the labeling. The result showed that the memory performance for these "filler faces" was lower in comparison to the androgynous faces. If a greater distinction between the androgynous faces and the female filler faces had been the reason for the female own-sex bias in Study III, we would expect to find less accurate face recognition for the female filler faces than for the male filler faces, which was not found. Thus, it is assumed that women attended to the androgynous faces more when they were labeled "women". Moreover, Study III employed a between-group design, thus, the same women were not tested in the female and the male experimental condition. For this reason, future research should try to replicate the current findings using a within-group study design.

8.5.2. Pre-testing

Research has shown that both degree of distinctiveness and heterogeneity within and across the set of face stimuli can influence later memory performance (e.g., Valentine & Bruce, 1986a). Pre-testing face stimuli can ascertain that faces within the experimental test are rated as equal in terms of distinctiveness (Sporer, 2001), so that different sets of face stimuli can be evaluated with respect to them being equally memorable (e.g., here female and male faces). Face distinctiveness has no bearing on the evaluation of sex differences in face recognition, whereas it can disturb the internal validity of the own-sex bias. Here, the interaction between gender and sex of the recognized face in both Study I and Study II was significant, hence, even if boys and men also more accurately remembered female faces than male faces, the effect was stronger for girls and women. It is therefore not likely that the female own-sex bias exist because female faces were generally easier to remember. In addition, boys recognized female and male Swedish faces to a similar degree, which would be unlikely if the female faces were more distinct and therefore easier to remember. However, future studies should include pre-testing of faces.

Based on pre-testing of the androgynous faces, it was shown that women and men did not perceive the androgynous faces differently. Thus, men and women rated the androgynous faces as portraying men or women to a similar degree ($p>.05$).

8.5.3. Measures

An obvious limitation with studies on sex differences is that the variable gender can not be manipulated. The main reason for including additional cognitive tasks in the studies was therefore to have control over potential confounding variables, such as overall differences in cognitive abilities. General word synonym tasks are known to be highly correlated with both general IQ scores and education and commonly yield no sex difference (Herlitz et al., 1997; Lezak, 1995; Malec, Ivnik, Smith et al., 1992). Thus, even though it is impossible to know whether differences in cognitive tasks not tested existed, the present designs allowed us to demonstrate that males and females displayed the expected similarities and differences regarding cognitive abilities (e.g., Halpern, 2000).

In summary: Although some of the findings in the present thesis warrant further investigation such as if the effects are present in non-western countries and for older women, there is good reason to believe that the current data can be generalized to women's and men's real-life face recognition ability.

8.6. Future research

In order to further test the assumption that attention modulates the female face recognition ability, future studies should investigate whether the female own-sex bias is less substantional when the attention load is high than when it is low. If women pay more attention to females than to males, manipulating attention at encoding of faces should render more detrimental effects on face recognition performance in women and in particular for women's recognition of female faces (see e.g., Craik, Govoni, Navhe-Benjamin & Anderson, 1996). Moreover, studies in which men's and women's faces are "competing" for attention, such as when male and female faces are presented together rather than in succession, should be conducted to establish if females' attention is directed towards females to a higher degree than towards males. In such a study, using eye-tracking devices for monitoring how and to what extent females and males attend to faces would be valuable.

The findings in the present thesis are based on behavioral data. With new techniques, such as fMRI, there has been a spurt in cognitive neuropsychological research in recent years. Such research has typically addressed questions concerning how faces are processed in the brain (e.g., Kanwisher et al., 1997). Of particular interest for the present findings would be to further explore, using fMRI, potential differences in the processing of female and male faces. In addition, future fMRI research should explore how high attention demands affect women's and men's ability to process female and male faces. Future research may be able to tell us whether fronto-parietal areas, such as prefrontal cortex and the inferior parietal lobe, known to be associated with attention (Cabeza & Nyberg, 2000), show greater activity in females than in males, especially during processing of female faces.

8.7. Summary and concluding remarks

Based on the results of the present thesis, several additional general conclusions can be drawn. First, gender can be considered to be one dimension in the multidimensional face-space model needed for face representation in memory. The initial multidimensional face-space model did not include such a specification (Valentine, 1991). However, our data show that female and male faces are not remembered equally well, and that the difference between remembering female or male faces is particularly large in females. This is in line with some recent studies in which processing and representation of female and male faces are distinct. Studies have shown that face distinctiveness is evaluated in relation to a gender-specific prototype rather than in relation to a general face-norm based on both female and male faces (Baudouin & Gallay, 2002; 2006; O'Toole, Deffenbacher, Valentin, McKee, Huff & Abdi, 1998).

Second, the main explanation for the own-group bias is based on the assumption that the bias is present for both groups investigated. Such a notion does not fit well with the current data, in which the own-sex bias was found in women, but not in men. Based on the findings in this thesis, it is less likely that the same explanations are valid for all types of own-group biases as previously have been suggested (see Sporer, 2001). The different patterns of performance seen in men and women with regard to own-sex bias, together with the dissociate pattern between the own-race and the own-sex bias seen in men (see Table 1), suggest that other causes and mechanisms may operate in the formation of own-sex bias, than in own-race bias. Studies on the own-race effect have shown that the amount of visual experience partly explains the effect (Meissner & Brigham, 2001), whereas the current research indicate that the own-sex bias is more likely driven by social cognitive explanations such as which individuals we attend to and further process and remember.

Third, the present data are of value for general theories of sex differences in cognition. Studying sex differences can be problematic, as it is often laden with stereotypical expectations regarding which sex should excel at which tasks (Steele, 1998). Face recognition performance may have the benefit of not being associated with such stereotypical beliefs. Moreover, the ability to remember faces is highly valuable to all humans, females and males alike. Nonetheless, the results in this thesis show that females and males do not recognize faces with equal proficiency. Importantly, the data is suggested to support the notion that the origin of sex differences derives both from our experiences and from biological dispositions, as predicted by the psychobiosocial model (e.g., Halpern, 2000).

Finally, it is important to state that all group differences should be applied to an individual with great caution. Other individual characteristic and contextual information should also be considered when predicting an individual's ability to recognize faces. Nevertheless, the data presented here show that girls and women generally outperform boys and men in face recognition and that sex differences favoring females are larger for female than for male faces. Moreover, girls and women consistently show an own-sex bias while males do not. Thus, based on past and present data, the pattern of sex differences across female and male faces can most likely be represented as in Figure 5, clearly demonstrating that gender, in several ways, play an important role in face recognition.

9. References

Astur, R. S., Ortiz., M. L., & Sutherland, R. J. (1998). A characterization of performance by men and women in a virtual Morris water maze: A large and reliable sex difference. *Behavior Brain Research*, *93*, 185-190.

Baddley, A. D. (1992). Working memory. *Science*, *255*, 556-559.

Baddley, A. D, & Hitch, G. J. (1974). Working memory. In G. A. Bower (Eds.), *Recent advances in learning and motivation*, Vol 8, (pp 47-90). New York: Academic Press.

Baenninger, M., & Newcombe, N. (1989). The role of experience in spatial test-performance: A meta-analysis. *Sex Roles, 20*, 5-6.

Bahrick, H. P., Bahrick, P. O., & Wittlinger, R. P. (1975). Fifty years of memory for names and faces: A cross-sectional approach. *Journal of Experimental Psychology: General*, *104*, 54-75.

Bandura, A., & Walters, R. H. (1963). *Social learning and personality development*. New York: Holt, Rinehart & Winston.

Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science, 17*(2), 159-163.

Bartfai, A., Nyman, H., & Stegman, B. (1992). *WAIS – R^S Wechsler Adult Intelligence Scale – Revised. David Wechsler Manual.* Sweden: Psykologiförlaget.

Barton, J. J., Press, D. Z., Keenan, J. P., & O'Connor, M. (2002). Lesions of the fusiform face area impair perception of facial configuration in prosopagnosia. *Neurology, 58*(1), 71-78.

Baudouin, J.-Y., & Gallay, M. (2002). Gender is a dimension of face recognition. *Journal of Experimental Psychology: Learning, Memory and Cognition, 28*, 362-365.

Baudouin, J.-Y., & Gallay, M. (2006). Is face distinctiveness gender based? *Journal of Experimental Psychology: Human Perception and Performance*, *32*, 789-798.

Bem, S. L. (1974). The measurement of psychological androgyny. *Journal of Consulting and Clinical Psychology*, *42*, 155-162.

Bem, S. L. (1981a). *Bem Sex Role Inventory: Professional manual*. Palo Alto, CA: Consulting Psychologists Press.

Bem, S. L. (1981b). Gender schema theory: A cognitive account for sex typing. *Psychological Review, 88*(4), 354-364.

Bentin, S., Allison, T., Puce, A., Pererz, E., & McCarthy, G. (1996). Electrophysiological studies on face perception in humans. *Journal of Cognitive Neuroscience*, *8,* 551-565.
Berenbaum, S. A., & Hines, M. (1992). Early androgens are related to childhood sex-typed toy preferences. *Psychological Science*, *3*, 203-206.
Bishop, K. M., & Wahlsten, D. (1997). Sex differences in the human corpus callosum: Myth or reality? *Neuroscience Biobehavior Reviews, 21*(5), 581-601.
Blaxton, T. A. (1995). A processed-based view of memory. *Journal of the international neuropsychological society, 1*, 112-114.
Bower, G. H., & Karlin, M. B. (1974). Depth of processing pictures of faces and recognition memory. *Journal of Experimental Psychology, 103*, 751-757.
Brigham, J. C., & Malpass, R. S. (1985). The role of experience and contact in the recognition of faces of own- and other race persons. *Journal of Social Issues*, *41*, 139-155.
Brigham, J. C., Maass, A., Snyder, L. D., & Spaulding, K. (1982). The accuracy of eyewitness identifications in field setting. *Journal of Personality and Social Psychology*, *42*, 673-681.
Brown, C., & Lloyd-Jones, TJ. (2006). Beneficial effects of verbalization and visual distinctiveness on remembering and knowing faces. *Memory & Cognition, 34*(2), 277-286.
Brown, E., & Perrett, D. I. (1993). What gives a face its gender? *Perception, 22*(7), 829-840.
Bruce, V., Burton, A. M., Hanna, E., Healey, P., Mason, O., Coombes, A., Fright, R., & Linney, A. (1993). Sex discrimination: how do we tell the difference between male and female faces? *Perception, 22*(2), 131-152.
Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology, 77*, 305-327.
Bruce, V., & Valentine, T. (1986). Semantic priming of familiar faces. *The Quarterly Journal of Experimental Psychology*, *38A*, 125-150.
Burton, A. M., Bruce, V., & Dench, N. (1993). What's the difference between men and women? Evidence from facial measurement. *Perception, 22*, 153-176.
Byatt, G., & Rhodes, G. (1998). Recognition of own-race and other-race caricatures: Implications for models of face recognition. *Vision Research*, *38*, 2455-2468.
Cabeza, R., & Nyberg, L. (2000). Imaging cognition II: An empirical review of 275 PET and fMRI studies. *Journal of Cognitive Neuroscience, 12*(1), 1-47.
Caldara, E., & Abdi, H. (2006). Simulating the "other race" effect with autoassociative neural networks: further evidence in favor of the face-space model. *Perception, 35*(5), 659-670.

Cann, A., & Newbern, S. R. (1984). Sex stereotype effects in children's picture recognition. *Child Development, 55,* 1085-1090.
Carey, S., Diamond, R., & Woods, B. (1980). The development of face recognition - A maturational component? *Developmental Psychology, 16*(4), 257-269.
Chance, J., Goldstein, A. G., & McBride, L. (1975). Differential experience and recognition memory for faces. *The Journal of Social Psychology, 97*, 243-253.
Cherney, I. D., & Ryalls, B. O. (1999). Gender-linked differences in the incidental memory of children and adults. *Journal of Experimental Child Psychology, 72*(4), 305-328.
Chiroro, P., & Valentine, T. (1995). An investigation of the contact hypothesis of the own-race bias in face recognition. *The Quarterly Journal of Experimental Psychology*, *48A*, 879-894.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* (Rev. ed). Hillsdale, NJ: Lawrence Erlbaum Associates.
Cohen, N. J., & Squire, L. R. (1980). Preserved learning and retention of pattern-analyzing skill in amnesia: Dissociation of knowing how and knowing what. *Science*, *210*, 207-210.
Cohen-Bendahan , C. C. C., van de Beek, C., & Berenbaum, S. A. (2005). Prenatal sex hormone effects on child and adult sex-typed behavior: methods and findings. *Neuroscience and Biobehavioral Reviews*, *29*, 353-384.
Collaer, M. L., & Hines, M. (1995). Human behavioral sex differences: A role for gonadal hormones during early development? *Psychological Bulletin, 118*(1), 55-107.
Colman, A. M. (2003). *Oxford dictionary of Psychology*. Oxford: Oxford University Press.
Connellan, J., Baron-Cohen, S., Wheelwright, S., Batki, A., & Ahluwalia, J. (2000). Sex differences in human neonatal social perception. *Infant Behavior & Development, 23*(1), 113-118.
Corenblum, B., & Meissner, C. A. (2006). Recognition of faces of ingroup and outgroup children and adults. *Journal of Experimental Child Psychology, 93*(3), 187-206.
Craik, F. I. M., Govoni, R., Naveh-Benjamin, M., & Anderson, N. D. (1996). The effects of divided attention on encoding and retrieval process in human memory. *Journal of Experimental Psychology: General, 125*, 159-180.
Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, *11*, 671-684.
Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General*, *104*, 268-294.

Cross, J. F., Cross, J., & Daly, J. (1971). Sex, race, age and beauty as factors in recognition of faces. *Perception & Psychophysics, 10,* 393-396.
Culp, R. E., Cook, A. S., & Housley, P. C. (1983). A comparison of observed and reported adult-infant interactions: Effects of perceived sex. *Sex Roles, 9*, 475-479.
Deaux, K., & Major, B. (1987). Putting gender into context: An interactive model of gender-related behavior. *Psychological Review, 94,* 369-389.
DeLisi, R., & Cammarano, D. M. (1996). Computer experience and gender differences in undergraduate mental rotation performance. *Computers in Human Behavior, 12*, 351-361.
Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*, *115*, 107-117.
Draganski, B., Gaser, C., Busch, V., Schuierer, C., Bogdahn, U., & May, A. (2004). Changes in grey matter induced by training. *Nature, 427*(22), 311-312.
Eccles, J. S., (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *Psychology of Women Quarterly, 18*, 585-609.
Ellis, H. D. (1975). Recognizing faces. *British Journal of Psychology*, *66*, 409-426.
Ellis, H. D., Shepherd, J., & Bruce, A. (1973). The effects of age and sex upon adolescents' recognition of faces. *The Journal of Genetic Psychology, 123*, 173-174.
Fagot, B. I., (1974). Sex differences in toddlers' behavior and parental reaction. *Developmental Psychology, 10,* 554-558.
Farah, M. J., (1990). *Visual agnosia: Disorders of object recognition and what they tell us about normal vision*. Cambridge, MA: MIT Press.
Farah, M. J., McMullen, P. A., & Meyer, M. M. (1991). Can recognition of living things be selectively impaired? *Neuropsychologia, 29*(2), 185-193.
Farah, M. J., Wilson, K. D., Drain, M., & Tanaka, J. N. (1998). What is "special" about face perception? *Psychological Review, 105*(3), 482-498.
Feinman, S., & Entwisle, D. R. (1976). Children's ability to recognize other children's faces. *Child Development, 47*, 506-510.
de Frias, C. M., Nilsson, L.-G., & Herlitz, A. (2006). Sex differences in cognition are stable over a 10-year period in adulthood and old age. *Aging Neuropsychology and Cognition, 13*(3-4), 574-587.
Frost, J. A., Binder, J. R., Springer, J. A., Hammeke, T. A., Bellgowan, P. S. F., Rao, S. M., & Cox, R. W. (1999). Language processing is

strongly left lateralized in both sexes. Evidence from functional MRI. *Brain, 122*, 199-208.
Fulton, A., & Bartlett, J. C. (1991). Young and old faces in young and old heads: The factor of age in face recognition. *Psychology & Aging, 6*(4), 623-630.
Gauthier, I., Behrmann, M., & Tarr, M. J. (1999). Can face recognition really be dissociated from object recognition? *Journal of Cognitive Neuroscience, 11*(4), 349-370.
Gauthier, I. & Bukach, C. (in press). Should we reject the expertise hypothesis? *Cognition.*
Gauthier, I., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). Expertise for cars and birds recruits brain areas involved in face recognition. *Nature: Neuroscience, 3*(2), 191-197.
Gauthier, I., Tarr, M. J., Anderson, A. W., Skudlarski, P., & Gore, J. C. (1999). Activation of the middle fusiform 'face area' increases with expertise in recognizing novel objects. *Nature: Neuroscience, 2*(6), 568-573.
Geary, D. C. (1999). Evolution and the developmental sex differences. *Current Directions in Psychological Science*, *8*, 115-120.
Gergen, M. M., & Davis, S. N. (1997). *Toward a new psychology of gender.* New York, NY; Routledge.
Gerstrof, D., Herlitz, A., & Smith, J. (2006). Stability of sex differences in cognition in advanced old age: The role of education and attrition. *Journal of Gerontology: Psychological Sciences, 61B*, 245-249.
Gibson, E. J. (1969). *Principles of perceptual learning and development.* New York: Appleton-Century-Crofts.
Going, M., & Read, J. D. (1974). Effects of uniqueness, sex of subject, and sex of photograph on facial recognition. *Perceptual and Motor Skills, 39*, 109-110.
Goldstein, A. G., & Chance, J. E. (1970). Visual recognition memory for complex configurations. *Perception & Psychophysics, 9*, 237-241.
Gough, B. (1998). Roles and discourse. In K. Trew., & J. Kramer (Eds.), *Gender & Psychology.* London: Arnold.
Grill-Spector, K., & Kanwisher, N. (2006). Visual recognition: As soon as you know it is there, you know what it is. *Psychological Science*, *16,* 152-160.
Grimshaw, G. M., Bryden, M. P., & Finegan, J.-A. K. (1995). Relations between prenatal testosterone and cerebral lateralization in children. *Neuropsychology, 9*, 68-79.
Halpern, D. F. (2000). *Sex differences in cognitive abilities* (3rd ed). Mahwah, NJ: Lawrence Erlbaum Associates.

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2000). The distributed human neural system for face perception. *Trends in Cognitive Science, 4,* 223-333.

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2002). Human neural system for face recognition and social communication. *Biological Psychiatry, 51*(1), 59-67.

Herlitz, A., Airaksinen, E., & Nordström, E. (1999). Sex differences in episodic memory: The impact of verbal and visuospatial ability. *Neuropsychology, 13*(4), 590-597.

Herlitz, A., & Kabir, Z. N. (2006). Sex differences in cognition among illiterate Bangladeshis: A comparison with literate Bangladeshis and Swedes. *Scandinavian Journal of Psychology*, *47*, 441-447.

Herlitz, A., Nilsson, L.-G., & Bäckman, L. (1997). Gender differences in episodic memory. *Memory & Cognition, 25*, 801-811.

Hill, R. D., Grut, M., Wahlin, Å., Herlitz, A., Winblad, B., Bäckman, L. (1995). Predicting memory performance in optimally healthy very old adults. *Journal of Mental Health and Aging, 1*, 55-65.

Hines, M. (1990). Gonadal hormones and human cognitive development. In J. Balthazart (Ed.)*, Brain and behavior in vertebrates 1: Sexual differentiation, neuroanatomical aspects, neurotransmitters, and neuropeptides* (pp 51-63). Basel, Schwitzerland: Karger.

Hogan, R., & Hogan, J. (1997). *HPI: Hogan Personality Inventory.* Tulsa: OK, Hogan Assessment Systems.

Hyde, J. S., & Linn, M. C. (1988). Gender differences in verbal ability: A meta-analysis. *Psychological Bulletin*, *104,* 53-69.

Johnson, M. H., Dziurawiec, S., Ellis, H., & Morton, J. (1991). Newborns' preferential tracking of face-like stimuli and its subsequent decline. *Cognition, 40*(1-2), 1-19.

Järpsten, B., & Taube, K. (1997). *DLS för klasserna 4-6.* Stockholm: Psykologförlaget AB.

Kaess, W. A., & Witroll, S. L. (1955). Memory for names and faces: A characteristic of social intelligence? *Journal of Applied Psychology*, *39*, 457-462.

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *Journal of Neuroscience, 17*(11), 4302-4311.

Kanwisher, N., Stanley, D., & Harris, A. (1999). The fusiform face area is selective for faces not animals. *Neuroreport, 10*, 183-187.

Laughery, K., Alexander, J. F., & Lane, A. B. (1971). Recognition of human faces: Effects of target exposure time, target position, pose position, and type of photograph. *Journal of Applied Psychology*, *5,* 477-483.

Leder, H., Schwarzer, G., & Langton, S. (2003). Development of face processing in early adolescence. In G. Schwarzer & H. Leder

(Eds.), *The development of face processing* (pp 69-80). Göttingen: Hogrefe & Huber.
Levin, D. T. (1996). Classifying faces by race: The structure of face categories. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *22*, 1364-1382.
Levin, D. T. (2000). Race as visual feature: Using visual search and perceptual discrimination tasks to understand face categories and the cross-race recognition deficit. *Journal of Experimental Psychology: General, 129*, 559-574.
Levin, D. T., & Angelone, B. L. (2001). Visual search for socially defined feature: What causes the search asymmetry favoring cross-race faces? *Perception & Psychophysics*, *63*, 423-435.
Levine, S. C., Huttenlocher, J., Taylor, A., & Langrock, A. (1999). Early sex differences in spatial skill. *Developmental Psychology, 35*(4), 940-949.
Levy, J. (1971). Lateral specialization of the human brain: Behavior manifestations and possible evolutionary basis. In J. Kriger Jr. (Ed.), *The biology of gender.* (pp 159-180). Corvallis: Oregon State University Press.
Lewin, C., & Herlitz, A. (2002). Sex differences in face recognition-Women's faces make the difference. *Brain and Cognition, 50*(1), 121-128.
Lewin, C., Wolgers, G., & Herlitz, A. (2001). Sex differences favoring women in verbal but not in visuospatial episodic memory. *Neuropsychology, 15*(2), 165-173.
Lezak, M. D. (1995). *Neurospychological assessment*. (3rd ed). Oxford: Oxford University Press.
Light, L. L., Kayra-Stuart, F., & Hollander, S. (1979). Recognition memory for typical and unusual faces. *Journal of Experimental Psychology: Human Learning and Memory, 5*, 212-228.
Lindholm, T. (2005). Own-age biases in verbal person memory. *Memory, 13*, 21-30.
Linn, M. C., & Petersen, A. C. (1986). A meta-analysis of gender differences in spatial abilities: Implications for mathematics and science achievement. In J. S. Hyde & M. C. Linn (Eds.), *The psychology of gender: Advances through meta-analysis* (pp 67-101). Baltimore: John Hopkins University Press.
Lippa, R. (1998). Gender-related individual differences and the structure of vocational interests: The importance of the people-things dimension. *Journal of Personality and Social Psychology, 74*(4), 996-1009.
Lorber, J. (1994). *Paradoxes of gender*. New Haven: CT: Yale University Press.

Lutchmaya, S., Baron-Cohen, S., & Raggatt, P. (2002). Foetal testosterone and eye contact in 12-month-old human infants. *Infant Behavior & Development*, *25*, 327-335.

Macchi Cassia, V., Keufner, D., Westerlund, A., & Nelson, C. A. (2006). A behavioural and ERP investigation of 3-month-olds' face preference. *Neuropsychologica, 44,* 2113-2125.

Macchi Cassia, V., Turati, C., & Simion, F. (2004). Can a nonspecific bias toward top-heavy patterns explain newborns' face preference? *Psychological Science, 15*(6), 379-383.

Maccoby, E. E., & Jacklin, C. N. (1974). *The psychology of sex differences*. Stanford, CA: Stanford University Press.

MacLin, O. H., & Malpass, R. S. (2001). Racial categorization of faces: The ambiguous race face effect. *Psychology, Public Policy, and Law*, *7*, 98-118.

Macmillan, N. A., & Creelman, C. D. (2004). *Detection theory: A user's guide* (2rd ed). Mahaway: NJ: Lawrence Erlbaum Associates.

Macrae, C. N., & Lewis, H. L. (2002). Do I know you? Processing orientation and face recognition. *Psychological Science, 13*(2), 194-196.

Magnusson, E. (2002). *Psykologi och kön: Från könsskillnader till genusperspektiv.* Finland: Natur och Kultur.

Malec, J. F., Ivnik, R. J., Smith, G. E., et al. (1992). Mayo's older American normative studies: Utility of corrections for age and education for WAIS-R. *The Clinical Neuropsychologist, 6* (suppl.)*,* 31-47.

McCarthy, G., Puce, A., Gore, J. C., & Allison, T. (1997). Face-specific processing in the human fusiform gyrus. *Journal of Cognitive Neuroscience, 9*, 605-610.

McClure, E. B. (2000). A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. *Psychological Bulletin, 126*(3), 424-453.

McGivern, R. F., Huston, J. P., Byrd, D., King, T., Siegle, G. J., & Reilly, J. (1997). Sex differences in visual recognition memory: Support for a sex-related difference in attention in adults and children. *Brain and Cognition, 34*(3), 323-336.

McGivern, R. F., Mutter, K. L., Anderson, J., Wideman, G., Bodnar, M., & Huston, P. J. (1998). Gender differences i incidental learning and visual recognition memory: support for sex differences in unconscious environmental awareness, *Personality and Individual Differences*, *25*, 223-232.

McKelvie, S. J. (1981). Sex differences in memory for faces. *The Journal of Psychology, 107*, 109-125.

McKelvie, S. J. (1987). Sex differences, lateral reversal, and pose as factors in recognition memory for photographs of faces. *The Journal of General Psychology*, *114*, 13-38.

McKelvie, S. J., Standing, L., St. Jean, D., & Law, J. (1993). Gender differences in recognition memory for faces and cars: Evidence for the interest hypothesis. *Bulletin of the Psychonomic Society, 31*, 447-448.

Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating own-race bias in memory for faces: A meta-analytic review. *Psychology, Public Policy, and Law, 7*, 3–35.

Michel, C., Rossion, B., Han, J., Chung, C.-S., & Caldara, R. (2006). Holistic processing is finely tuned for faces of one's own race. *Psychological Science, 17*(7), 608-614.

Mitchell, D. B. (2006). Nonconscious priming after 17 years. Invulnerable implicit memory? *Psychological Science, 17*(11), 925-929.

Morris, P. E., & Wickham, L. H. V. (2003). Attractiveness, distinctiveness, and recognition of faces: Attractive faces can be typical or distinctive but are not better recognized. *American Journal of Psychology*, *116*, 455-468.

Morton, J., & Johnson, M. H. (1991). CONSPEC and CONLEARN: A two-process theory of infant face recognition. *Psychological Review*, *98,* 164-181.

Mäntylä, T., & Nilsson, L.-G. (1988). Cue distinctiveness and forgetting: Effectiveness of self-generated retrieval cues in delayed recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14*, 502-509.

Nilsson, L.-G., Bäckman, L., Erngrund, K., & Nyberg, L et al. (1997). The Betula prospective cohort study: Memory, health, and aging. *Aging, Neuropsycholog and Cognition. 4*, 1-32.

Nyberg, L. (2002). *Kognitiv neurovetenskap: Studier av sambandet mellan hjärnaktivitet och mentala processer.* Lund: Studentlitteratur.

Nyberg, L., Forkstam, C., Petersson, K. M., Cabeza, R., & Ingvar, M. (2002). Brain imaging of human memory systems: between-systems similarities and within-system differences. *Cognitive Brain Research, 13*(2), 281-292.

O'Toole, A. J., Deffenbacher, K., Valentin, D., McKee, K., Huff, D., & Abdi, H. (1998). The perception of face gender: The role of stimulus structure in recognition and classification. *Memory & Cognition, 26*, 146-160.

Palermo, R., & Rhodes, G. (in press). Are you always on my mind? A review of how face perception and attention interact. *Neuropsychologia*.

Pegna, A. J., Khateb, A., Michel, C. M., & Landis, T. (2004). Visual recognition of faces, objects, and words using degraded stimuli: Where and when it occurs. *Human Brain Mapping*, *22*, 300-311.

Pezdek, K., Blandon-Gitlin, I., & Moore, C. (2003). Children's face recognition memory: More evidence for the cross-race effect. *Journal of Applied Psychology, 88*(4), 760-763.

Posamentier, M. T., & Abdi, H. (2003). Processing faces and facial expressions. *Neuropsychology Review, 13*(3), 113-143.

Postma, A., Jager, G., Kessels, R. P. C., Koppeschaar, H. P., & van Honk, J. (2004). Sex differences for selective forms of spatial memory. *Brain and Cognition, 54*(1), 24-34.

Quinn, P. C., Yahr, J., Kuhn, A., Slater, A. M., & Pascalis, O. (2002). Representation of the gender of human faces by infants: A preference for female. *Perception, 31*, 1109-1121.

Rakover, S. S., & Cahlon, B. (2001). *Face recognition: cognitive and computational process. Advances in consciousness research*. Amsterdam: John Benjamin Publishing.

Ramsey, J. L., Langlois, J. H., & Marti, N. C. (2005). Infant categorization of faces: Ladies first. *Developmental Review*, *25*, 212-246.

Repovs, G., & Baddley, A. (2006). The multi-component model of working memory: Explorations in experimental cognitive psychology. *Neuroscience, 139*(1), 5-21.

Rhodes, G., Brake, S., & Atkinson, A. P. (1993). What's lost in inverted faces? *Cognition, 47*(1), 25-57.

Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. *Annual Review of Psychology, 39,* 475-543

Robbins, R., & McKone, E. (in press). No face-like processing for objects-of expertise in three behavioural tasks. *Cognition.*

Rodin, M. J. (1987). Who is memorable to whom: A study of cognitive disregard. *Social Cognition, 5*, 144-165.

Roediger, H. L. (1990). Implicit memory: Retention without remembering. *American Psychologist*, *45*, 1043-1056.

Roediger, H, L., Buckner, R. L., & McDermott, K. B. (1999). Components of processing. In J. K. Foster & M. Jelicic (Eds.), Memory: Systems, process or function? (pp 31-65). Oxford: Oxford University Press.

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, *35*, 677-688.

Sangrigoli, S., & De Schonen, S. (2004). Recognition of own-race and other-race faces by three-month-old infants. *Journal of Child Psychology and Psychiatry, 45*(7), 1219-1227.

Sangrigoli, S., Pallier, C., Argenti, A.-M., Ventureyra, V. A. G., & de Schonen, S. (2005). Reversibility of the other-race effect in face recognition during childhood. *Psychological Science, 16*(6), 440-444.

Schacter, D., & Tulving, E. (1994). What are the memory systems of 1994? In D. L. Schacter & E. Tulving (Eds.), *Memory systems 1994* (pp1-38). Cambridge, MA: MIT Press.

Schooler, J. W., & Engstler-Schooler, T. Y. (1990). Verbal overshadowing of visual memories: Some things are better left unsaid, *Cognitive Psychology*, *22*, 36-71

Schretlen, D. J., Pearlson, G. D., Anthony, J. C., & Yates, K. O. (2005). Determinants of Benton facial recognition test: Performance in normal adults. *Neuropsychology*, *15*, 405-410.

Sergent, J. (1984). An investigation into component and configural processing underlying face perception. *British Journal of Psychology*, *75*, 221-242.

Servin, A., Bohlin, G., & Berlin, L. (1999). Sex differences in 1-, 3-, 5-year-olds' toy-choice in a structured play-session. *Scandinavian Journal of Psychology, 40*, 43-48.

Shapiro, P. N., & Penrod, S. (1986). Meta-analysis of facial identification studies. *Psychological Bulletin, 100,* 139 – 156.

Shepherd, J. W., & Deregowski, J. B. (1981). Races and faces- a comparison of the responses of Africans and Europeans to faces of the same and different races. *British Journal of Social Psychology*, *20*, 125-133.

Sherman, A. M., de Vries, B., & Lansford, J. E. (2000). Friendship in childhood and adulthood: Lessons across the life span. *The International Journal of Aging and Human Development, 51*, 31-51.

Signorella, M. L., & Liben, L. S. (1984). Recall and reconstruction of gender-related pictures: Effects of attitude, task difficulty, and age. *Child Development, 55*(2), 393-405.

Silverman, I., & Eals, M. (1992). Sex differences in spatial abilities: Evolutionary theory and data. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp 533-549). New York: Oxford University press.

Slone, A. E., Brigham J. C., & Meissner, C. A. (2000). Social and cognitive factors affecting the own-race bias in whites. *Basic and Applied Social Psychology*, *22*, 71-84.

Spaniol, J., Madden, D. J., & Voss, A. (2006). A diffusion model analysis of adult age differences in episodic and semantic long-term memory retrieval. *Journal of Experimental Psychology; Learning, Memory and Cognition, 32*(1), 101-117.

Sporer, S. L. (2001). Recognizing faces of other ethnic groups: An integration of theories. *Psychology, Public Policy, and Law, 7*, 36-97.

Squire, L. R. (1992). Memory and the hippocampus: A synthesis from findings from rats, monkeys and humans. *Psychological Review*, *99*, 195-231.

Steele, C. M. (1998). Stereotyping and its threat are real. *American Psychologist*, *53*, 680-681.

Stein, B. S., & Bransford, J. D. (1979). Constraints on effective elaboration: Effects of precision and subject generation. *Journal of Verbal Learning and Verbal Behavior, 18*, 769-777.

Strand, S., Deary, I. J., & Smith, P. (2006). Sex differences in cognitive abilities test scores: A UK national picture. *British Journal of Educational Psychology, 76,* 463-480.
Sugisaki, Y., & Brown, W. (1916). The correlation between the sex of observers and the sex of pictures recognized. *Journal of Experimental Psychology, 1,* 351-354.
Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: A meta-analysis. *Psychological Bulletin*, *121*, 371-394.
Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *The Quarterly Journal of Experimental Psychology A, 46*(2), 225-245.
Tanaka, J. W., Kiefer, M., & Bukach, C. M. (2004). A holistic account of the own-race effect in face recognition: evidence from a cross-cultural study. *Cognition, 93*(1), B1-B9.
Tanaka, J. W., & Sengco, J. A. (1997). Features and their configuration in face recognition. *Memory & Cognition, 25*(5), 583-592.
Terlecki, M. S., & Newcombe, N. S. (2005). How important is the digital divide? The relation of computer and videogame usage to gender differences in mental rotation ability. *Sex Roles*, *53*, 433-441.
Thilers, P. P., MacDonald, S. W. S., & Herlitz, A. (2006). The association between endogenous free testosterone and cognitive performance: A population-based study in 35 to 90-year-old men and women. *Psychoneuroendocrinology, 31,* 565-576.
Thompson-Schill, S. L., Braver, T. S., & Jonides, J. (2005). Individual differences. *Cognitive, Affective & Bahavioral Neuroscience, 5,* 115-116.
Tulving, E. (1983). *Elements of episodic memory.* Oxford: Oxford University Press.
Tulving, E. (1993). Human memory. In P. Andersen, O. Hvalby, O. Paulsen, & B. Hökfelt. (Eds.), *Memory concepts: Basic and clinical aspects.* (pp 27–46). Amsterdam: Elsevier.
Turati, C., Valenza, E., Leo, I., & Simion, F. (2005). Three-month-olds' visual preference for faces and its underlying visual processing mechanisms. *Journal of Experimental Child Psychology, 90*(3), 255-273.
Unger, R., & Crawford, M. (1996). *Women and gender: A feminist psychology* (2nd ed). The McGraw-Hill Companies.
Valenca, E., Simion, F., Macchi Cassia, V., & Umiltà, C. (1996). Face preference at birth. *Journal of Experimental Psychology: Human Perception and Performance, 22,* 892-903.
Valentine, T. (1988). Upside-down faces: A review of the effect of inversion upon face recognition. *British Journal of Psychology*, *79*, 471-491.
Valentine, T. (1991). A unified account of the effects of distinctiveness, inversion, and race in face recognition. *The Quarterly Journal of Experimental Psychology A, 43*(2), 161-204.

Valentine, T., & Bruce, V. (1986a). Recognizing familiar faces: The role of distinctiveness and familiarity. Canadian Journal of Psychology, *40*, 300-305.

Valentine, T., & Bruce, V. (1988). Mental rotation of faces. *Memory & Cognition, 16*(6), 556-566.

Valentine, T., & Endo, M. (1992). Towards an exemplar model of face processing: The effects of race and distinctiveness. *The Quarterly Journal of Experimental Psychology, 44A*, 671-703.

Vandenberg, S. G. (1971). *A test of three-dimensional spatial visualization based on the Shephard-Metzler "mental rotation" study*. Boulder: University of Colorado.

Vikingstad, E. M., George, K. P., Johnson, A. F., & Cao, Y. (2000). Cortical language lateralization in right handed normal subjects using functional magnetic resonance imaging. *Journal of Neurological Sciences, 175*(1), 17-27.

Vokey, J. R., & Read, D. J. (1988). Typicality, familiarity and the recognition of male and female faces. *Canadian Journal of Psychology, 42,* 489-495.

Voyer, D. (1996). On the magnitude of laterality effects and sex differences in functional lateralities. *Laterality*, *1,* 51-83.

Voyer, D., Voyer, S., & Bryden, M. P. (1995). Magnitude of sex differences in spatial abilities: A meta-analysis and consideration of critical variables. *Psychological Bulletin, 117*(2), 250-270.

Wechsler, D. (1981). *Wechsler Adult Intelligence Scale-Revised: Manual.* New York: Psychological Corporation.

Whalin, Å., Bäckman, L., Mäntylä, T., Herlitz, A., Viitanen, M., Winblad, B. (1993). Prior knowledge and face recognition in a community-based sample of healthy, very old adults. *Journal of Gerontology: Psychological science, 48*, 54-61.

Winograd, E. (1978). Encoding operations which facilitate memory for faces across the life span. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds). *Practical aspects of memory* (pp 255-262). New York: Academic Press.

Winograd, E. (1981). Elaboration and distinctiveness in memory for faces. *Journal of Experimental Psychology: Human Learning and Memory, 7*, 181-190.

Wood, W., & Eagly, A. H. (2002). A cross-cultural analysis of the behavior of women and men: Implications for the origin of sex differences. *Psychological Bulletin, 128*, 699-727.

Wright, D. B., Boyd, C. E., & Tredoux, C. G. (2003). Inter-racial contact and the other race-bias for face recognition in South Africa and England. *Applied Cognitive Psychology*, *17*, 365-373.

Wright, D. B., & Sladden, B. (2003). An own gender bias and the importance of hair in face recognition. *Acta Psychologica, 114*(1), 101-114.

Wright, D. B., & Stroud, J. N. (2002). Age differences in lineup identification accuracy: People are better with their own age. *Law and Human Behavior, 26*(6), 641-654.
Yamaguchi, M. K., Hirukawa, T., & Kanazawa, S. (1995). Judgment of gender through facial parts. *Perception, 24*(5), 563-575.
Yarmey, D. A. (1974). Proactive interference in short-term retention of human faces. *Canadian Journal of Psychology*, *28*, 333-338.
Yin, R. K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology*, *81*, 141-145.
Yonker, J. E., Eriksson, E., Nilsson, L.-G., & Herlitz, A. (2003). Sex differences in episodic memory: Minimal influence of estradiol. *Brain and Cognition, 52*, 231-238.
Young, A. W., Hellaway, D., & Hay, D. C. (1987). Configural information in face perception. *Perception*, *16*, 747-759.