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BEHAVIOURAL AND NEUROSCIENTIFIC
SEX DIFFERENCES IN EMPATHY
Abstract

Empathy is a multidimensional phenomenon that consists of both emotional and cognitive components. This paper gives an overview of behavioural and neuroscientific sex differences in empathy, as well as potential explanations to those results. Research indicates existence of sex differences in both emotional and cognitive empathy, although inconsistent findings suggest both female superiority as well as male superiority. Gender roles, social desirability, as well deficiencies in measurement and imprecise conceptualizations of empathy is argued as contributors to found sex differences. With a restricted amount of research on sex differences in empathy, inconsistent findings as well as a great proportion of critique towards both the research field of empathy as well as towards focus on sex differences; the authors argue that presented sex differences in empathy must be interpreted with a great caution.

Keywords: empathy, sex, gender difference, behaviour, neuroscience
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Introduction

With a difficult history characterized of both discrepancy and disagreements, there is still no general agreement of the concept of empathy. Nevertheless, research on empathy display consistent empirical data in relation to a wide range of species (Preston & de Waal, 2002). Further, empathy is a vital element of social cognition, and social cognition is essential for mental health. In light of this, it has been argued that it is important to investigate sex differences (SD) in the neural mechanisms underlying empathy; more specifically referring to that mapping SD in empathy might contribute to resolve the neurobiological bases of many psychiatric disorders that differ between female and male (e.g. autism, antisocial personality disorder, depression etc.) (Christov-Moore et al., 2014).

The terms sex and gender are used interchangeably within the research fields of psychology, developmental, and neurocognitive sciences. For simplicity and consistency, as well as with the purpose to emphasize the biological perspective taken, the author will refer to sex differences throughout the paper, more specifically meaning biological differences between females and males.

The aim of the paper is to give an overview of behavioural, psychological and neuroscientific SD in empathy. First, the author will define the concept of empathy. Further, evolutionary and developmental perspectives of empathy will be reviewed. Moreover, an overview of behavioural and psychological SD in empathy will be presented. Further, neuroscientific SD in empathy will be presented in line with the model of empathy proposed by Decety and colleagues (Decety & Jackson, 2004; Decety & Moriguchi, 2007). Potential explanations to the research findings presented will be proposed. Discussion of content and limitations of findings will be followed by concluding remarks and future directions.
Defining Empathy

Empathy is a multidimensional phenomenon that has been studied for hundreds of years, and generally is agreed to be a fundamental component of our social and emotional lives (Preston & de Waal, 2002; Decety & Cowell, 2014). Still, there is no agreement among researchers about a definition of empathy. Despite this, there is a general view of that empathy consists of both emotional and cognitive components (e.g. Baron-Cohen & Wheelwright, 2004; Berglund & Annett, in press; Decety & Jackson, 2004; Shamay-Tsoory, Aharon-Peretz, & Perry, 2009;).

The emotional component of empathy refers to the ability to experience similar emotional states as the emotional states in another person, further meaning having the capacity to get affectively aroused by the other person’s emotions. The concept of sharing emotions with another person is also referred to as affective resonance (AR) and emotion contagion (EC) (Decety & Cowell, 2014).

The cognitive component of empathy refers to a more cognitive role-taking ability, meaning being able to engage in the cognitive process of adopting the psychological point of view of another person (Frith & Singer, 2008). The capacity to create a theory of another persons’ mental state and further cognitively take the perspective of that person is a more complex form of empathy than emotional empathy (Shamay-Tsoory, 2011). Cognitive empathy further involves abilities such as theory of mind (ToM), the capacity to put oneself into another persons’ shoes and imagine their feelings and thoughts (Baron-Cohen, 2009).

Although researchers mostly agree that empathy contain both emotional and cognitive aspects, there are differing opinions in how the two aspects relate to each other. Researchers such as Baron-Cohen and Wheelwright (2004), Shamay-Tsoory et al. (2009), Shamay-Tsoory (2011) as well as Hoffman (2011), view the two components of empathy as
potentially distinct, meaning that the emotional and cognitive components must not necessarily be simultaneously present.

For example, Baron-Cohen (2002) has put forward the Empathizing-Systemizing Theory (E-S theory), suggesting that while females more commonly empathize, males preferably more often systemize. While empathizing refers to the drive to identify the emotions and thoughts of another person, as well as respond appropriately to this emotion, systemizing is more of an inductive process, where systemizing refers to gathering information to further draw certain predictions from.

Furthermore, Shamay-Tsoory and colleagues (Shamay-Tsoory, 2011; Shamay-Tsoory et al., 2009) has proposed there are two dissociable systems of empathy. The first system refers to a basic emotional contagion system that enable us to empathize emotionally, while the second system is described as a more advanced cognitive perspective-taking system, enable us to understand perspectives of other people.

In contrast to both Baron-Cohen (2002) and Shamay-Tsoory and colleagues (Shamay-Tsoory, 2011; Shamay-Tsoory et al., 2009), Berglund and Annett (in press) argue that there cannot be cognitive empathic processes without any emotional elements. Despite arguing against the conceptually detachment of emotional and cognitive empathy, Berglund and Annett (in press) albeit refer to the anatomically and physiologically evidence that support the view of emotional and cognitive empathy as built upon distinct neural correlates (see e.g. Shamay-Tsoory, 2011).

Further, Berglund and Annett (in press) request a rejection of the conceptualization of emotional and cognitive empathy as a dichotomy, and instead propose the view of the concept of empathy as containing both emotional and cognitive elements. This is in line with an empathy model proposed of Decety and Jackson in 2004, where the researchers presented the following subcomponents to being intertwined and compelled to
work together to produce the subjective experience of empathy: affective sharing, self-other awareness, and mental flexibility. This model was refined in 2007 by Decety and Moriguchi, resulting in the addition of the component regulatory, referring more specifically to emotion regulation.

Throughout the thesis, the author will refer to both emotional and cognitive components of empathy as proposed by Berglund and Annett (in press), use aspects proposed by both Baron-Cohen (2002) and Shamay-Tsoory and colleagues (Shamay-Tsoory, 2011; Shamay-Tsoory et al., 2009). Still, the main perspective on empathy will be based on the model of empathy proposed by Decety and colleagues (Decety & Jackson, 2004; Decety & Moriguchi, 2007).

**Evolutionary and Developmental Perspective on Empathy**

Empathy is an ancient biological phenomenon stemming from the practice of caregiving, especially in species where survival of offspring depends on a prolonged postnatal caring from the mother (Preston & de Waal, 2002). When offspring show emotions indicating feelings of hunger, stress, pain or fear, the ability to perceive and respond with care towards offspring is to act and understand basic empathic behaviour (Decety, Norman, Berntson, & Cacioppo, 2012). The human infant has an innate biological system for endorsing proximity seeking of a figure to attach to. Infants inborn system aim at increasing the probability of survival to a reproductive age, and is more commonly called attachment (Sroufe, 2000).

Moreover, empathy did not become a capacity exclusively for parent and offspring. Rather, once the ability of empathy had evolved, the capacity further got disconnected from its ultimate goal (de Waal, 2008). In addition, empathy has roots in group living (Decety, 2015). The ability to communicate with one another, sharing information of intentions and emotions and further respond correctly to relatives and offspring in need, have been essentially for the mammalian reproductive fitness and survival (Decety et al.,
2012). Depending on the social relationship and context, empathy not only promote affective communication, but also may contribute with motivation to pro-social behaviour towards other conspecifics (Decety, 2011).

With basis in Decety and Moriguchi’s (2007) model of empathy, evolutionary and developmental perspectives of empathy will be presented below.

**Affective Sharing**

EC, also referred to as mimicry, is an automatically appearing ability to adopt the emotional state of another person, and further agreed as the most basic form of empathy (Berglund & Annett, in press; Christov-Moore, et al., 2014). One adaptive advantage of humans ability to unconsciously and unintentionally mimic behaviours (e.g. rate of speech, tone of voice, posture etc.), is that it bind people together and cultivate liking, interaction and empathy (Decety & Jackson, 2004). In comparison to more advanced cognitive capacities, basic affective circuits in the brain developed much earlier (Decety & Svetlova, 2012).

The involuntary and rapid response when a person mimics another persons’ facial expression is referred to as rapid facial mimicry (RFM) (Mancini, Ferrari, & Palagi, 2013). In a study on non-ape species, the Gelada, results showed that both the highest level of RFM and fastest responses took place between mother and infant (Mancini et al., 2013). Another mimicry behaviour is the contagious yawning, found in both human, non-human animals, e.g. apes and non-ape gelada baboon (Palagi, Leone, Mancini, & Ferrari, 2009). In relation to gelada baboons, the contagious yawning has been proposed to be more frequent between the baboons that are in a closer relationship to each other, further proposed as support for a nonhuman primate experience of empathy (Palagi et al., 2009). Moreover, in relation to SD, the results showed that yawn contagion was especially noticeable in relation to adult females, and that females exhibited more matching yawn types than did males.
Researchers’ interpret the findings as potential support for deeper bond between females than males (Palagi et al., 2009). Further SD in EC will be reviewed later.

In relation to humans, human infants are biologically predisposed to affectively resonate with basic positive and negative affective states of others (Decety & Svetlova, 2012). For example, one study found that when a calm infant heard the sound of another neonate cry, the calm infant started crying. Moreover, they found that newborn babies responses were both species- and peer-specific, and further that the babies could discriminate between their own and other infants’ crying. The results show evidence for that human infant exhibits rudimentary EC (Marin & Clark, 1982).

Further, there is support for SD in EC in human infants. Neonatal imitation is a phenomenon that aims at newborn babies’ imitation of facial expressions (e.g. fear, surprise, sadness)(Field, Woodson, Greenberg, & Cohen, 1982). In relation to newborn infants (3-96 hours old), researchers found that girls in comparison to boys, have more fine motor movements, as well as exhibit a greater amount of specific imitative gestures. Additionally, in comparison to boys, girls respond faster during imitation. Researchers argue that girls, as both more accurate and faster in relation to imitative skills, might attain better social environment (e.g. responsive and interactive) in comparison to boys (Nagy, Compagne, Orvos, & Pal, 2007). More SD in EC will be presented further below.

In relation to other species, humans exhibit more complex and advanced levels of empathy; this coupled to self-awareness and perspective-taking, and further coupled to the maturation of the prefrontal cortex (PFC) and its reciprocal relation to the limbic system (Decety & Svetlova, 2012).

Self-Other Awareness

In addition to EC, to acquire a complete empathic experience, one must be able to distinguish oneself from another (Decety & Meyer, 2008). Humans have an ability to
understand that the self and other people are similar, but yet separate; we do seldom confuse first-person knowledge with third-person knowledge. This is an ability that starts to develop around the second year of life (Decety & Svetlova, 2012), and the skill enable one to learn to use the knowledge about the self to infer about other people’s mental states (Decety & Jackson, 2004). The ability of self-awareness and hence a clear sense of self are supposed to have developed to solve two adaptation problems; 1) though the self is an “archive” of social feedback we have received from others, the self become a major impact in guiding adaptive interpersonal strategies; 2) the self contribute with an understanding of other people’s subjective world (Forgas & Williams, 2014).

According to de Waal (2008), the ability to recognize oneself from a mirror, might be a capacity that coevolved with empathy. In order to be able to recognize oneself, one must understand that one’s own reflection in the mirror represents oneself, not another individual (Prior, Schwarz, Günrürkün, 2008). Self-recognition has been found in for examples chimpanzees (Suarez & Gallup, 1981). From this finding, the researchers also concluded that other apes did not exhibit this ability, and further made them speculate that the self-recognition ability might not extend below humans and great apes. But in 2001, researchers found self-recognition ability in dolphins (Reiss & Marino, 2001), and later also in the European Magpie, Pica pica, supporting the notion that the neocortex in not necessary to the self-recognition ability (Prior et al., 2008).

**Mental Flexibility**

Perspective taking is the human cognitive capacity to intentionally adopt the subjective perspective of another person to represent their knowledge or emotional experience as compared to one’s own knowledge and emotional experience (Decety et al., 2012). It has been argued that the development of perspective-taking occur around the same age as the emergence of self-recognition, based on the both abilities’ need for secondary representations
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Asendorpf, Warkentin, & Baudonnière, 1996). Further, when comparing younger and older adolescents, results show that younger score lower on the factor Perspective taking, and higher on Personal distress as measured by Interpersonal Reactivity Index (IRI) (Davis, 1980) (Hawk et al., 2013). Furthermore, females scored higher on each subscale mentioned, and Empathic concern, in comparison to males.

Another concept related to mental flexibility is theory of mind (ToM). ToM, also referred to as mentalizing, is the ability to make implicit assumptions about the behaviours of other people based on one’s own desires, attitudes and beliefs (Frith & Frith, 2003). The evolutionary perspective on ToM suggests that the ability must have evolved from the capacity to monitor biological motion and from imitation behaviours (Abu-Akel, 2003). Although it has been suggested that chimpanzees exhibit ToM (Premack & Woodruff, 1978), the ability to mentalize is almost exclusively a human capacity (Gallagher & Frith, 2003).

Researchers argue that children around three to six years old, develop a new cognitive skill that enable them to understand the concept of deception, as well as understand other people’s beliefs and potential consequences of those beliefs although that might be in conflict with either reality or the observing child’s beliefs (Wellman, Cross, & Watson, 2001; Wimmer & Perner, 1983).

Regulatory Processes

As earlier stated, one important aspect of empathy is the ability to disentangle oneself from others in a sense of self-other awareness, with the aim to avoid emotional distress or anxiety, emotions that are not a part of the subjective experience of empathy (Decety & Jackson, 2006). Moreover, there are clear adaptive advantages of the ability to regulate one’s own emotions, both for the individual and the species (Eisenberg et al., 1994). Researchers have showed that being able to regulate one’s emotions increase the likelihood of both experience empathy as well as act in morally desirable ways (Eisenberg, Smith,
Sadovsky, & Spinrad, 2004). Regulating one’s emotions are referred to cognitive top-down mechanisms that either aim at up-regulate or down-regulate emotions (Decety & Lamm, 2006).

All developmental periods consist of some regulatory processes, because emotions incorporate regulatory processes (Thompson, 2011). Although, self-regulation as well as emotional arousal is both influenced by the early maturation of the attentional systems. These attentional systems enable voluntary control and the capacity to disengage from emotionally arousing events (Rothbart, 2007). Moreover, the context is important in understanding how emotional regulatory systems functions, both from a behaviourally and neurobiological perspective. For example, cultural values, expectations, and situational demands can shape emotional regulatory processes (Rothbart, 2007).

Furthermore, the hypothalamic pituitary adrenocortical (HPA) axis has been suggested as influence regulatory processes as well (Thompson, 2011). This system helps to account for decreasing emotional lability and enable a greater self-control (Gunnar & Quevedo, 2007). Furthermore, the system is functional already in newborn’s but mature significantly during the first years of life (Gunnar & Quevedo, 2007).

Moreover, oxytocin (OT) has been suggested as down-regulating the HPA axis (Decety & Svetlova, 2012). OT is a small neuropeptide (Acher, 1996), which physiologically influence on both emotions, behavioural states and on the autonomic nervous system (Decety & Svetlova, 2012). For example, intranasal administration of OT in humans has been shown to increase trust and thereby increase the benefits from social interactions (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005). Although, other researchers have recommended a more cautious approach towards OT, referring to the unlikeliness of a widely acting hormone as OT to be funnelled to regulate mental processes specified for social cognition (Churchland & Winkielman, 2012).
In addition to the components of empathy suggested by Decety and Moriguchi (2007), the author will additionally go through the following components from an evolutionary and developmental perspective; pro-social behaviour and play.

**Pro-Social Behaviour**

Pro-social behaviour refers to actions that aim at benefit or helping another person or a group of persons (Decety et al., 2012). A motivator for pro-social behaviour in human is ECN (Decety & Jackson, 2004). ECN can be evoked by the understanding and sharing of an emotional state with another person (Echols & Correll, 2012), meaning perspective-taking could be a motivator for ECN (Batson et al., 2003). ECN has been observed in children in the second year in life, where the children more specifically have developed affective, cognitive and behavioural capacities that enable concern for others in distress (Bretherton, Frith, Zahn-Waxler, & Ridgeway, 1986). Pro-social behaviour has been observed in both primates and other animals, as well as in humans, where behaviour such as offering each other support when in need, repair relationship after conflicts etc. has been argued as a sign of pro-social behaviour (Christov-Moore et al., 2014).

For example, a study investigating underlying motivation towards pro-social behaviour in great apes, researchers focused on examining if helping behaviour were more common towards conspecifics that had been harmed (vs. not harmed), comparing four species of great apes (Liebal, Vaish, Haun & Tomasello, 2014). Although orangutans (but not chimpanzees, gorillas and bonobos) exhibited more pro-social behaviour towards conspecifics that has been harmed, compared to conspecifics that have not been harmed, researchers conclude that overall great apes did not help more after a conspecific being harmed (Liebal et al., 2014).
Play Behaviour

Play behaviour is argued to have developed to help children establish friendship and get along with peers, develop fit bodies and strong bones, learn to control emotions and impulses, as well as to learn and practice cultural skills and values (LaFreniere, 2011). In relation to caregiving explored through play behaviour, there are studies indicating that SD arises early in the human development (Christov-Moore et al., 2014). Although humans share biology with primates, the aspect of socialization is argued as an important factor by developmental psychologists, in relation to SD in play behaviour (LaFreniere, 2011).

In wild primate chimpanzees, SD appeared in juveniles in relation to play with objects. Carrying sticks were seen as a primitive act of doll play, and this behaviour was more common in females compared to males. The researchers suggest that the SD are due to that stick-carrying is a form of play-mothering, hence the behaviour more prevalent in females than males. Further the researchers suggest that the chimpanzees did not learn the stick-carrying behaviour from adults, thus do they dismiss a more socialization focus view of explanation (Kahlenberg & Wrangham, 2010). In line with this, earlier studies in vervet monkey show similar results, with females playing with “feminine” toys, and males playing with “masculine” toys more often, a behaviour researchers’ argue arise outside the influence of social and cognitive mechanisms (Alexander & Hines, 2002).

An evolutionary and developmental background of empathy has been presented. Next section will present findings of behavioural and psychological SD in empathy, based on how research fields such as psychology, economy, and cognitive neuroscience divide and approach the concept of empathy.
Behavioural and Psychological Sex Differences in Empathy

One way to approach investigating SD in empathy could be to divide the concept to smaller pieces (Michalska, Kinzler, & Decety, 2013). Concepts that will be presented are emotion recognition (ER), mentalizing, ToM, and pro-social behaviour.

Emotion Recognition

The ability to recognize emotional expressions is a crucial cognitive capacity that enables humans to regulate emotionality in social interactions. In being able to appropriately orient our own behaviour in a social context, cues such as facial expressions as well as tone of the voice serves as fundamental guidelines (Collignon et al., 2010).

SD in psychological and physiological responses has been empirically observed in relation to a range of emotional stimuli (Stevens and Hamann, 2012). However, observed variability in experimental literature on affective SD might partly be explained by whether an emotion is negative (unpleasant) or positive (pleasant). More specifically, there have been more consistently observed SD in relation to negative emotions (NE), compared to the prevalence of SD observed in relation to positive emotions (PE) (Stevens & Hamann, 2012).

For example, researchers have found that girls rate aversive pictures as more unpleasant than boys do, while they do not rate neither neutral nor positive pictures as more pleasant than boys (Sharp, Van Goozen, & Goodyer, 2006). The same study found that children’s arousal rating to unpleasant pictures also increased with age, this unrelated to SD. This was not observed in relation to neutral or pleasant pictures (Sharp et al., 2006).

Furthermore, from a review of SD in several observed emotion expressions from infancy to adolescence, researchers found very small, but still significant “… gender-role-consistent gender differences overall” (Chaplin, & Aldao, 2013, p. 754). While girls express more PE as well as more internalizing NE (e.g. anxiety, sadness), boys express more externalizing emotions (e.g. anger). Factors such as age, interpersonal context, and task type,
all contextual factors contributed to changes in these small SD they found. The researchers suggest that the pattern of emotion expression that girls exhibit, might contribute to an increase of girls’ probability of developing symptoms of anxiety and depression, as well as contribute to their greater prosociality, compared to boys (Chaplin, & Aldao, 2013).

Below, ER will be reviewed through research focusing on facial expressions, body language, and socioemotional priming.

**Facial expression.**

Facial emotions serve meaningful cues in social communication by providing information about the character of the relationship between the interacting partners, as well as give information about the sender’s emotional and intentional state. These facial emotions serve as information that enables us to correctly recognise other people’s emotions, which is a crucial factor in experiencing positive social interactions (Keltner & Kring, 1998).

With the aim to investigate multisensory processing (auditory, visually, or audio-visually) of emotional expressions, participants’ were asked to categorize disgust and fear expressions from dynamic visual and non-linguistic vocal clips of facial expressions. Data from 46 participants (23 females and 23 males) indicated that females, under all stimulus conditions, had an advantage in comparison to males. Researchers conclude there exist SD in regard to multisensory perception of emotion expression (Collignon et al., 2010).

Another study investigated the perception of emotional facial expressions. Results revealed that females in comparison to males were both more accurate and in addition also more sensitive in labelling facial expressions (Montagne, Kessels, Frigerio, de Haan, & Perrett, 2005). Furthermore, females have been observed as better able to recognize subtle emotional expression when comparing with male (Hoffman, Kessler, Eppel, Rukavina, & Traue, 2010). Although, these results were only true in regard to subtle emotional expressions, while not in relation to full-blown emotions. Hence, the authors conclude that SD
in relation to ER depend on the intensity of the presented emotional expression (Hoffman et al., 2010.)

Hampson, van Anders, and Mullin (2006) conducted a study resulting in conclusion that females are both faster and better at recognizing PE and NE from facial cues, than are males. The authors discuss the underlying mechanisms for the result and conclude that females’ superiority is not due to neither SD in simple perceptual speed, or previous experience of childcare. Rather, they suggest this be due to an evolved adaptation linked to caring for preverbal offspring (Hampson et al., 2006).

With the aim to investigate recognition errors when reading facial emotional displays, Thayer and Johnsen (2000), found that females in comparison to males, have a more differentiated representation of emotions. Results indicated that females could distinguish between different emotions regardless of the sex of the face displaying the emotion. Further, researchers report that females potentially use subtle differences in arousal when trying to extract affective information from a face displaying an emotion (Thayer & Johnsen, 2000).

**Body language.**

In contrast to facial expressions of emotions, bodily expressions give people immediate knowledge about what specific action is coupled or associated with that specific emotion, and decrease the need for interpretation (De Gelder, 2006).

With the aim to investigate potential SD in different socio-cognitive tasks, participants were tested on recognition of distinct features from point light displays (PLDs) that displayed bodily movements (Alaerts, Nackaerts, Mayns, Swinnen, & Wenderoth, 2011). In comparison to males, females were better on PLD perception tasks involving both bodily ER, and bodily action recognition (Alaerts et al., 2011).

In the similar manner, another study used PLD when investigating if there exist SD in bodily emotional expressions, and further, how these differences gets modulated by sex
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(Sokolov, Krüger, Enck, Krägeloh-Mann, & Pavlova, 2011). Researchers conclude existence of SD in relation to body language reading, with females more accurate in reading bodily emotions in comparison to males. No effect was found in relation to speed of body language reading (Sokolov et al., 2011).

**Socioemotional priming.**

Socioemotional priming is a way to investigate whether facial emotional stimuli has an impact on impressions, although presented outside conscious awareness (Donges, Kersting, & Suslow, 2012).

With the aim to examine the effect of sex on affective priming based on positive (happy) and negative (sad) facial expressions, researchers presented either happy or sad facial expressions under the threshold of subjective conscious perception (33 ms.) (Donges et al., 2012). Further, researchers showed the 81 participants (53 females, 28 males) a neutral face that the subject had to evaluate. Results implicated that females in comparison to males, had a greater ability to both perceive and respond to positive facial emotions, based on females stronger positive evaluate shift in the happy prime condition. Emotional priming did not seem to affect the male group in any priming condition, neither positive nor negative. The researchers suggest that even without conscious awareness, females are able to recognize positive valence of facial emotion (Donges et al., 2012).

In relation to ER in different moods, a study suggested that male recognize emotions better when they are in a happy mood, compared to when in a sad mood. In comparison, female’s ability to recognize emotions were not affected by their mood. In line with one of the researchers hypothesis, females further performed better in the ER task than did male (Schmid, Schmid, Bombari, Mast, & Lobmaier, 2011). Furthermore, from eye tracking device, the researchers conclude that females process information more globally and less locally, than male do, meaning females and male use different processing styles. The
researchers suggest their results as data supporting behavioural data for SD in information processing when scanning faces (Schmid et al., 2011).

SD in ER, and more specifically in regard to facial expression, body language, and socioemotional priming has been overviewed. Females seem to, in comparison to males, be better at multisensory perception of emotions expression (Collignon et al., 2010), better able to recognize subtle emotional expressions (Hoffman et al., 2010), be both faster and better at recognizing PE and NE from facial cues (Hampson et al., 2006), and further have a more differentiated representation of emotions (Thayer & Johnsen, 2000).

In relation to body language, females in comparison to males, seen to be better in perception tasks involving both bodily emotions and action recognition (Alaerts et al., 2011), as well as more accurate in reading bodily emotions (Sokolov et al., 2011). In relation to socioemotional priming, females in comparison to males, had greater ability to both perceive and respond to positive facial emotions (Donges et al., 2012), as well as were not as much affected by their mood as males when recognizing emotions (Schmid et al., 2011).

**Mentalizing/Theory of Mind**

As previously described, mentalizing, also referred to as ToM, aim at the cognitive part of empathy, enabling understanding of what another person’s thinking or feeling due to the capacity to put oneself into the mind of another (Decety, 2015). There are inconsistent findings in regard to SD in ToM, and further relatively few studies investigating ToM in adults. Nevertheless, there are studies examine ToM in children (Christov-Moore, 2014).

A study examining ToM in 50 adults (25 females and 25 male) showed that females in comparison to males performed significantly better in ToM-test (Baron-Cohen, Joliffe, Mortimore, & Robertson, 1997). In line with these results, a study investigating ToM in one hundred eleven 3-5 years old children (63 girls and 48 boys) showed that girls in
comparison to boys, scored higher on ToM-tests. The same study further concluded that ToM understanding predicted pro-social behaviour for girls, and aggressive or disruptive behaviour for boys (Walker, 2005).

In contrast to these results, one study investigating ToM in 60 adult participants (30 females and 30 male) did not find any SD in relation to ToM (Jarrold, Butler, Cottington, & Jimenez, 2000). Furthermore, another study investigating ToM in 80 adult participants (40 females and 40 male), showed that male in comparison to females were superior in their performance in ToM (Russell, Tchanturia, Rahman, & Schmidt, 2007).

Overall, there are inconsistent results in ToM. Some studies show that adult females as well as girl are better in ToM abilities than are male and boys (Baron-Cohen et al., 1997; Walker, 2005), while other studies do not support SD in ToM in adults at all (Jarrold et al., 2000), or on the contrary show results indicating adult male are superior in ToM in comparison to females (Russel et al., 2007).

**Pro-Social Behaviour**

Pro-social behaviours, such as helping, sharing and comforting another person, are all actions that are intended to benefit another person (Bartal, Decety, & Mason, 2011). As previous mentioned, prosocial behaviours could be motivated by ECN (Decety & Jackson, 2004).

There is research supporting that girl are more pro-social than boys (Baumrind, 1980). From a review article on SD in relation to peer relationships, the authors conclude that girls in comparison to boys, have relationships that are characterized by pro-social behaviour to a great extend, a pattern that seem to increase with age (Rose & Rudolph, 2006). Furthermore, girls in comparison to boys seem to be more sensitive to distress observed in other people, as well as tend to be more likely to seek support, express their emotions, as well as ruminate in response to the stress (Rose & Rudolph, 2006).
Economic games are frequently used when studying pro-social behaviour in adult human. One economic game is the Ultimatum Game, where a proposer and responder divide an amount of money between them, based on the proposer’s proposal of a division of the total sum of money. The responder’s task is to either rejects the offer, consequently both get zero, or accept the money meaning that both get the money. There is a tendency to reject the offer when it’s perceived as unfair (Christov-Moore et al., 2014). Similar to the Ultimatum Game, there is the Dictator game where the main difference from the Ultimatum game is that the receiver must always accept the offer (Christov-Moore, 2014).

SD in pro-social behaviour will be reviewed from the perspective of economic and voluntary behaviour.

**Economic behaviour.**

When facing a situation of making decisions, people usually have to front some risks. Compelling evidence from psychology and sociology suggest that females are more averse to risks than are males (Croson & Gneezy, 2009). A meta-analysis conducted by Byrnes, Miller, and Schafer (1999) analysed 150 studies in regard to risk-taking tendencies in female and male subjects in relation to different settings. Based on over 100,000 participants, the authors conclude that male participants were more likely to take risks than female participants, although more specifically authors argue that SD varied according to both age level and context (Byrnes et al., 1999).

Furthermore, with the aim to study behavioural SD in relation to the Ultimatum Game, researchers conclude that there is systematic SD (Eckel & Grossman, 2001). Results suggest that females are significantly more cooperative, based on that females are more willing to accept a given offer, than are males. Moreover, the researchers propose context as
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an important factor, referring to that the sex of the respondent’s partner effect the subject’s decision. More specifically, the offers’ are most likely to be accepted when proposed by a female opponent. Female’s proposals are further more often more generous than compared to male’s offers, but this independent of the sex of the respondent. This further meaning, females’ both get rejected and reject less frequently, than do males, and make the authors to argue that this builds strong solidarity between females (Eckel & Grossman, 2001).

Although, in contrast to these results, another study using the Ultimatum Game showed that females’ get rejected by both other females and male, more often than are male. Furthermore, the lowest acceptance frequency was found in the pairing of female-female (Solnick, 2001).

From a study using the Dictator Game, researcher conclude that females on are less selfish, as well as donate twice as much to an anonymous partner, in comparison to male (Eckel & Grossman, 1998). In another study using the Dictator Game, researchers conclude that knowing the sex of the person the participant gives money to affects the amount given. Although, this was only true for females, not male, and more specifically observed females giving less to females than to male and persons of unknown sex (Ben-Ner, Kong, & Putterman, 2004).

Overall, males are more willing to take risks than are females (Byrnes et al., 1999; Croson & Gneezy, 2009). Furthermore, there are inconsistent findings in relation to economic games. While some researchers suggests that females tend to be more cooperative, more generous in their economic offers, and tend to less often both get rejected and self reject economic offers, in comparison to males (Eckel & Grossman, 2001), others suggest that females get rejected by both sexes more often than do males (Solnick, 2001). Moreover,
females are less selfish, donate more money (Enckel & Grossman, 1998), and get more affected in their economic decisions by the sex of the recipient (Ben-Ner et al., 2004).

Economic games such as the Ultimatum Game and the Dictator game may be argued to have little ecological validity. But there is research supporting these experimental findings, more specifically research studies that examine voluntary behaviour (Christov-Moore et al., 2014).

**Voluntary behaviour.**

Bekkers and Wiepking (2011) have suggested several mechanisms that enable people to give. One study chose two of the suggested mechanisms, ECN and the principle of care, and examined them in relation to giving and potential SD (Mesch, Brown, Moore, & Hayat, 2011). Overall, both ECN and the principle of care were mechanisms that affected giving, more specifically meaning both mechanisms were positively related to giving in both sexes. Furthermore, results showed SD in relation to both what motivates females and males to give, and also suggest that these differences influences actual charity giving. Results showed that females scored higher on both ECN and the principle of care, and were both more capable to give and also give more, in comparison to male (Mesch et al., 2011).

Another study aimed at studying whether or not sex, race and/or marital status influence giving and voluntary behaviour (Mesch, Rooney, Steinberg, & Denton, 2006). When controlling for differences in age, income, educational attainment and survey methodology, researchers found that single females were more likely to give at all, and further also to give more than single male. In a similar manner, single females in comparison to single male, were more likely to volunteer, and further also volunteer more hours than single male. Both married females and male in relation to single male were more willing to donate,
albeit not more money than single male. The researchers highlight the interesting results referring to the fact that both married and single female are associated with an increase in likelihood of giving, indicating that females potentially socialize males in relation to philanthropic giving (Mesch et al., 2006).

To summarize, females score higher in both ECN and principle of care, are more capable to give and further give more money, than do males (Mesch et al., 2011). In addition, both single and married females are more willing to give, in comparison to males, whereas single males are most less likely to give (Mesch et al., 2006). Single females are also more likely to volunteer as well volunteer more hours than single male (Mesch et al., 2006).

Evolutionary background, developmental perspective, as well as psychological and behavioural SD, all in relation to empathy, have been presented. Next, there will be a review of neuroscientific SD in empathy.

**Neuroscientific Sex Differences of Empathy**

As previously discussed, the concept of empathy can be approached from different perspectives. Baron-Cohen (2002) and the proposed E-S theory, as well as Shamay-Tsoory (Shamay-Tsoory, 2011; Shamay-Tsoory et al., 2009) and the dissociable system of empathy, view the emotional and cognitive components of empathy as separable at times. Other researchers such as Berglund and Annett (in press) view the emotional and cognitive components as intertwined, meaning cognitive empathy cannot exist without emotional elements. Although Berglund and Annett (in press) deny the conceptual detachment of emotional and cognitive empathy, they still, in line with Baron-Cohen (2002) and Shamay-Tsoory (2011) approach neuroscientific underpinnings of empathy with focus on the emotional and cognitive distinct neural correlates.
The model of empathy proposed of Decety and colleagues (Decety & Jackson, 2004; Decety & Moriguchi, 2007) is based on theories and data from behavioural neurology, developmental psychology and cognitive neuroscience. As previously discussed, their model contain the following subcomponents of empathy; (1) affective sharing, (2) self-other awareness, (3) mental flexibility, and (4) regulatory processes (Decety & Moriguchi, 2007). With basis in Decety and colleagues model of empathy, neuroscientific SD in empathy will be reviewed.

From en cognitive neuroscientific perspective, empathy is often approached from either an affective (pre-reflective) or a cognitive (reflective) point of view (Christov-Moore et al., 2014). The affective components of empathy are often examined through preconscious mechanisms underlying and facilitating sharing (and mimicry) of both behaviours and other people’s mental states, often referred to as mirroring (Zaki & Ochsner, 2012). Affective empathy is generally associated with sensation, movement and emotions, and is further related to activity in frontoparietal, temporal and subcortical regions (Zaki & Ochsner, 2012).

In contrast, the cognitive components are investigated through conscious processes from what assumptions about other people’s affective and bodily states, beliefs and intentions can be made, often referred to as mentalizing (Christov-Moore, 2014; Zaki & Ochsner, 2012). Cognitive empathy is associated with decision-making and cognitive control, tasks that are associated with activity in areas such as the cingulate, prefrontal, and temporal areas (Zaki & Ochsner, 2012).

Research support that the experience of empathy is facilitated through an interaction between the mirroring and mentalizing areas, rather than enabled from the two distinct systems alone (Christov-Moore et al., 2014). Furthermore, from a developmental perspective, the affective components develop earlier than both the cognitive and regulatory
components (Decety, 2011).

The neuroscientific section begins with an overview of neuroanatomical sex differences in the brain. Moreover, based on the model of empathy proposed of Decety and colleagues (Decety & Jackson, 2004; Decety & Moriguchi, 2007), a review of the neuroscientific underpinnings of the previous mentioned components of empathy will be presented, followed by an overview of the neuroscientific SD observed in relation to those specific components.

Neuroanatomical Overview of Sex Differences in the Brain

There are different theories concerning emotion and brain. For example, researchers have suggested that both hemispheres process emotions, but that e.g. PE is mainly enabled through the left hemisphere, and NE are specialized through the right hemisphere (Gur, Skolnick, & Gur, 1994). Other theories have suggested that the left hemisphere is specialized on cognitive processes while the right hemisphere is mainly concerned with emotion processing (Wager, Phan, Liberzon, & Taylor, 2003). Although, a quantitative meta-analyses of 65 neuroimaging studies of emotion, and concluded that the emotional brain is much more complex and region specific than what has been suggested from previous hemisphere-level hypothesis (Wager et al., 2003).

Furthermore, females in comparison to males exhibit more gray matter (GM) volume in the cingulate cortex, traditionally part of the limbic system. More specifically, females had increased GM volume near the depths of both the central sulci as well as the left superior temporal sulcus, in right Heschl’s gyrus and planum temporale, in right inferior frontal and frontomarginal gyri and in the cingulate gyrus. Furthermore, females had increased GM concentration in the cortical mantle, parahippocampal gyri, and in the banks of the cingulate and calcarine sulci (Good et al., 2001). Furthermore, researchers have found that the mirror neuron system (MNS) display SD in regarding neuroanatomical volume (Cheng et al.,
2009). In comparison to males, females exhibit larger GM volumes in the right inferior frontal gyrus (IFG), and in the pars opercularis and inferior parietal lobule (IPL) of the RH, structures suggested as core areas of the MNS, and further located near the MNS (10 mm) (Cheng et al., 2009). Moreover, females exhibited greater GM volumes in brain regions associated with social information processing, such as bilateral posterior inferior frontal and left anterior mPFC (Yamasue et al., 2008). In comparison, males showed increased GM volume bilaterally in mesial temporal lobes, entorhinal and perirhinal cortex, and in the anterior lobes in the cerebellum. No increased GM concentration was found in males (Good et al., 2001).

Older studies support these findings, suggesting females, in comparison to males, have a higher percentage of GM (Gur et al., 1999). Further, males in comparison with females, exhibit a higher percentage of white matter (WM) and cerebrospinal fluid. The percentage of GM in male were higher in the left hemisphere, while the WM was symmetric across both hemispheres. The percentage of cerebrospinal fluid was higher in the right hemisphere in male. These asymmetries were not observed in females. Researchers conclude that the sex differences and asymmetry of GM, WM, and cerebrospinal fluid could be a factor contributing to differences in cognitive functioning (Gur et al., 1999). Furthermore, males exhibited larger amygdala and cerebellum volumes. Females with larger volume of the MNS also had greater volume in the social brain regions Cheng et al., 2009).

To summarize; Females in comparison to males exhibit more GM volume in the cingulate cortex, pars opercularis, IPL of the RH, and in parts of the mPFC, as well as have increased GM concentration in areas such as the cortical mantle parahipocampal gyri and in the banks of the cingulate and calcarine sulci (Cheng et al., 2009; Good et al., 2001). Males show increased GM volume in bilateral mesial temporal lobes, entorhinal and perirhinal cortex, and in the anterior lobes in the cerebellum (Good et al., 2001). Further, males have higher percentage of WM and cerebrospinal fluid, as well as larger amygdala and cerebellum
volumes in comparison to females (Cheng et al., 2009; Gur et al., 1999).

Below, SD in relation to the subcomponents of empathy suggested of Decety and colleagues will be presented (Decety & Jackson, 2004; Decety & Moriguchi, 2007).

**Affective Sharing**

As a component of affective empathy, affective sharing refers to the emotional sharing between self and other, enabled by a perception-action connection resulting in shared representations (Decety & Jackson, 2004). Shared representations between perception and action have both behavioural and neurophysiological evidence (Decety & Jackson, 2004). For example, infants have an innate capability to imitate from birth, which has been suggested as robust evidence for the perception-action coupling. This simple motor resonance behaviour mechanism, this neural activity automatically activated when observing gestures, movements etc., cannot though solely explain infants’ ability to imitate from birth. Rather, infants’ capability of imitation has come to be considered as a social response (Decety & Jackson, 2004). Structures such as the amygdala, thalamus (TH) and the orbitofrontal cortex (OFC) are considered to play a crucial role in relation to the perception-action connection. Furthermore, the reciprocal connection between amygdala and OFC, and the superior temporal sulcus (STS) enable a fast processing of affective information (Decety, 2011).

Sex differences in affective sharing will be reviewed through research findings in relation to MNS, EC, and pain.

**Mirror Neurons.**

From a study on Macaque monkeys, researchers found neurons in the rostral part of iPFC (F5) that fire both when the monkey themselves engage in specific hand movements (e.g. grasping and holding) as well as when the monkey observe the experimenter
execute specific and meaningful hand movements (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rozzolatti, 1992). This discovery of the so-called mirror neurons has been considered as a breakthrough in neuroscience, with the finding contributing to the research field with a better understanding of the brains ability to feel what one would feel during the execution of a similar action as the one observed (Keysers & Fadiga, 2008).

Although derived from indirect evidence, functional imagining studies have proposed that humans exhibit mirror neurons as well. More specifically, mirror neurons have been observed in area 44 (Brocca’s area) and the nearby ventral area 6 (Rizzolatti & Craughero, 2004). Area 44 has been argued to be cytarchitechtonically homologous to the F5 in the PMC (Petrides, Cadoret, & Mackey, 2005), an area that has been reported as central to the human MNS (Rizolatti, 2005). In another study, researchers used extracellular recording of 1177 cells in the medial frontal and temporal cortices in humans. The results made researchers conclude that neural mirror mechanisms exist in multiple systems in the human brain, with the aim to flexible integrate and differentiate perceptual and motor aspects of action executed by the self and other (Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). The mirror neurons importance for emotion perception is supported by e.g. one study that, in relation to observation and imitation of facial expressions of emotion, observed activation in IFG (Carr, Iacoboni, Duben, Mazziota, & Lenzi, 2003).

In relation to SD, a study using fMRI on 26 participants (14 females and 12 males), argue that their results support the notion that females recruit areas containing mirror neurons to a higher degree than do males, in face-to-face interaction (Schulte-Rüther, Markowitsch, Shah, Fink, & Piefke, 2008). Furthermore, as previous mentioned, MRI studies show evidence of that females, in comparison to males, exhibit larger GM volumes in the pars opercularis and IPL of the right hemisphere, all areas involved in the MNS (Cheng et al., 2009).
With background in that females are considered to be superior in interpersonal sensitivity compared to males, and that the MNS is thought to contribute with the basic mechanisms for social cognition, researchers did an EEG study indicating existence of SD in MNS during action observation (Cheng et al., 2008). More specifically, the mu rhythm was used as an indicator of the MNS activity, with the background of that mu suppression elicited by watching hand actions is considered to indicate specific recruitment of the MNS. EEG activity was measured in 40 participants (20 females and 20 males) while observed either a moving dot or hand movements. Results showed that females displayed significantly greater mu suppression when watching hand actions, compared to males. The mu suppression further negatively correlated with the systemizing quotient (SQ) that measure the systemizing aspect based on the E-S theory (Baron-Cohen, 2002), and positively correlated with the personal distress subscale in the IRI (Cheng et al., 2008).

To summarize, mirror neurons is argued to have been found in area 44 in humans, an area cytoarchitectonically homologous to the F5 in the PMC (Petrides et al., 2005). Other researchers have argued that mirror neurons exist in multiple systems in the human brain (Mukamel et al., 2010). Further, mirror neurons are crucial for emotion perception, based on findings of mirror neurons in IFG (Carr et al., 2003).

In face-to-face interaction, females recruit mirror neurons to a higher degree than do males (Shulte-Rüter et al., 2008). Females also have larger GM volumes in areas associated with the MNS, such as the pars opercularis and the IPL of the RH (Cheng et al., 2009). Furthermore, females recruit mirror neurons to a greater extent when observing hand movement, in comparison to males (Cheng et al., 2008).
Emotion contagion.

Bodily and facial expressions communicate similar information and are both important and natural parts of the everyday life, as well as have strong biological underpinnings (de Gelder et al., 2010).

From a review article on electrophysiological recording in neurosurgical patients, authors argue that social perception are dependent on the STS, an area that seems to be specialized for encoding complex visual stimuli, such as eyes and faces (Allison, Puce, & McCarthy, 2000). Additionally, the researchers point out that STS is anatomically well placed in relation for integration of information from the dorsal and ventral visual pathways.

Furthermore, in relation to face perception, researchers have suggested amygdala as a central structure for the processing of social relevant information, especially in regard to potential threat (Haxby, Hoffman, & Gobbini, 2002). For example, a study with the aim to investigate the neural mechanisms underlying the human ability to detect more complex facial expressions, researchers used a test of detection on participants with lesions to the temporal lobe (54 participants) or frontal lobe (31 participants)(Shaw et al., 2005). Researchers found that impairment in recognition of both cognitive and social expressions was related to damage in both left and right amygdala. Furthermore, the ability to recognize complex social expressions with negative valence was impaired in relation to damage to the whole right PFC. Researchers conclude that the ability to process a wide range of emotional expressions, from basic to more complex cognitive and social expressions, depend on the contribution of amygdala (Shaw et al., 2005).

Based on psychological studies, there is evidence for that female in comparison with males has better memory of emotional events. With this background, researchers wanted to investigate potential neuronal SD in relation to the female superiority in emotional memory. Researchers used fMRI on 24 participants (12 females and 12 males) while asked to
rate their experienced emotional arousal in relation to either emotionally negative or neutral pictures (Canli, Desmond, Zheo, & Gabrieli, 2002).

In a follow up three weeks after, participants did a recognition memory test, showing both females and males remembered emotional pictures the most, although females remembered them better than males. Furthermore, the results showed that in relation to encoding stimuli effectively into memory, females used significantly fewer brain structures involving the left amygdala, than did males, while males used more structures in a network including the right amygdala in relation to the same purpose. Moreover, both while on going evaluation of emotional experience as well as with subsequent memory for the most emotionally arousing pictures, females showed significantly more brain regions activated, compared to males, which might explain why females have better emotional memory than males (Canli et al., 2002).

Another study used fMRI with the aim to investigate SD in the brain activity in regard to emotions elicited by (1) facial expressions and whole body images, (2) video clips, and (3) further investigate the role of the sex of both observer and the one stimulus display (Kret, Pichon, Grézes, & De Gelder, 2011). The results showed that when participants observed male versus female actors expressing threat, the BOLD signal was higher in STS (associated with face and body perception), extrastriate body area (EBA)(important for body perception), and pre-supplementary motor area (pre-SMA)(involved in action preparation), and PMC.

Furthermore, in the regions mentioned, plus fusiform gyrus (associated with face and body perception), researchers found an interaction between category, emotion and observer, indicating that male participants showed more activation if they were presented with the male threatening in comparison to the neural body. Moreover, the highest activity in STS was triggered by threatening bodies, not faces, also this particularly in male participants. In
relation to the EBA, male participants responded more to threatening body expressions than did females. The activation in amygdala was in comparison to bodily expressions, greater in facial expressions, no matter what kind of emotions observed. This was especially true for males that were presented with female faces. Concluding remarks from the researchers was their emphasis of the importance of whether a body or face is presented in relation human emotion perception, as well as the importance of the sex of both observer and the observed (Kret et al., 2011).

In conclusion, STS is an area crucial for social perception and encoding complex visual stimuli such as eyes and faces (Allison et al., 2000). Furthermore, amygdala is an important structure for processing both basic and complex cognitive and social information (Haxby et al., 2002; Shaw et al., 2005). Moreover, the PFC is important for recognition of social expressions with negative valence (Shaw et al., 2005).

In relation to SD in emotion memory, when evaluating and consolidating memory, females recruit more brain regions than do male (Canli et al., 2002). Females remember better as well recruit fewer brain areas involving the left amygdala to consolidate stimuli into memory, than male. Male use more structures in a network including the right amygdala than females do. (Canli et al., 2002).

Factors such as whether body or face, female or male express emotions, affect the brain responses in the observer (Kret et al., 2011). When male express threat, higher activation is observed in STS, EBA, the pre-supplementary motor areas, and PMC, in both sexes. Threatening bodies (vs. faces) cultivate the greatest activity in, especially in male, who further responded more to bodily threatening expressions than did females, cultivating increased activity in EBA. Amygdala becomes activated more to facial expressions (vs bodily), especially in male presented with female faces (Kret et al., 2011).
With background in that emotional tone of voice display the significance of the communicated utterance, researchers investigated whether participants were able to recognize this significance although attending to something else. Of special interest for the researchers, was potential SD in regard to this. Analysis of ERP data from 80 participants’ showed that both female and male were able to detect voice changes preattentively (Schirmer, Striano, & Friederici, 2005).

Although, SD were detectable, suggesting that females exhibited larger mismatch negativity in relation to emotional deviants than to neutral deviants. More specifically, researchers conclude that females in comparison to male show enhanced emotional processing at a relatively early and automatized stage where information is still unattended (Schirmer et al., 2005).

**Pain.**

Pain expressions can serve as an important signal to motivate helping behaviours in other people. Therefore, investigating how people perceive others in pain can be a way to examine the neural mechanisms enabling empathy. Furthermore, there are studies indicating that several brain areas are involved in the processing of both the observation of pain in other people, as well as in the affective and motivational aspects if one’s own pain (Decety & Jackson, 2006).

One study used fMRI to (1) test for unique and shared networks for experienced and empathic pain (Singer et al., 2004). The researchers conclude that the rostral anterior cingulate cortex (rACC) and anterior insula (AI) cortices, both areas associated with activation for noxious stimuli play an important role in the experience of empathy. Pain-related activation was found in primary somatosensory cortex (SI), secondary somatosensory cortex (SII), bilateral insula cortex, ACC, TH, brainstem and cerebellum.
When empathizing with others in pain, only part of the pain-related network was activated, more specifically in left and right AI, ACC, lateral cerebellum and brainstem. The authors view their empathy-related findings as support for an automatically triggered engagement in empathic processes when people observe others in pain. Areas such as contralateral SI, SII/posterior insula, and caudal ACC are pain-related areas more specifically activated in relation to the experience of self-pain than perception of others-pain (Singer et al., 2004). In line with these results, Morrison, Lloyd, Pellegrino, and Roberts (2004) conducted a fMRI study showing that the right dorsal ACC was activated when participants experienced moderately painful pinprick stimulus to the fingertips, as well as when they only observed another person’s hand undergo similar stimulation.

Two years later, Singer et al. (2006) investigated if and in that case how, the neuronal systems that underlie our own bodily and emotional states when empathizing, could be modulated by the social relations between individuals. By using the economic game model Prisoner’s Dilemma (PDG), with confederates’ actors either playing fair or unfair, the researcher induced liking or disliking in the participants. After, by using fMRI on the participants, the researchers investigated if the liking or disliking could modulate empathic responses for pain, through applying painful stimulation to the confederates.

When observing unfamiliar but fair-playing person in pain, there was pain-related empathy related activity, more specifically in AI ranging into fronto-insular cortex (FI) and brainstem, in both sexes. While the ACC activation were more borderline in male, the ACC activation in females was significant. Those male and females exhibiting higher empathy-related bran activity in AI/FI and ACC, also displayed higher scores on standard empathy scale22 (Singer et al., 2006).
Furthermore, results showed that when an unfair player was exposed to pain, there was less empathy-related activity in the observer. This reduction of activity was very small in females, while significant in male. When comparing fair and unfair players receiving pain, females did not differ in activation in empathy related pain regions. On the contrary, a significant increase in activation in bilateral FI was observed in males when a fair player was observed getting pain, compared to observed non-fair players in pain (Singer et al., 2006).

In addition to these results, male showed increased activation in left ventral striatum/nucleus accumbens (VS/NA), and left orbitofrontal cortex (OFC), areas related to reward-processing, when researchers compared the painful trials in the fair and unfair-condition. Male showed significantly higher activation in left NA in comparison to females, when comparing painful trials in the unfair and fair condition. Further, not true for females, but males, there was a greater activation in NA when perceiving an unfair player getting painful stimuli (versus perceived fair player in pain), which also correlated positively with a stronger desire for revenge measured by post-experiment questionnaires measuring a subjectively expressed desire for revenge. This was not found in females. Both VS/NA and OFC have been considered to be reward-processing areas (Singer et al., 2006).

Another study used EEG with the aim to investigate SD in neural mechanisms underlying empathy for pain, where the researchers’ compared event-related brain potentials (ERP) between females and male (Han, Fan, & Mao, 2008). Pictures of hands that were either in neutral or painful situations were presented for participants. The subjects were asked to perform a pain judgement task that either demand attention to perform a counting task that withdrew their attention from the pain cues, or focus their attention to pain cues in the presented stimuli. 140 ms after stimulus onset, there was a short-latency empathic response over the frontal lobe, signalling differentiation between neutral and painful stimuli, both in
female and male. 380 ms after stimulus onset there was a long-latency empathic response in both male and female, over the central-parietal regions.

Although, in comparison to male, females showed stronger modulation by task demands in the long-latency empathic response. Furthermore, the subjective reports of the degree of perceived pain of others and of unpleasantness of the self correlated with the ERP amplitudes at 140-180 ms, only in females not in males. Researchers conclude that their study provide ERP evidence for SD in processes of empathy for pain (Han et al., 2008).

To summarize, brain areas such as ACC and AI are important for the experience of empathy. Some parts of the pain-related network are activated when empathizing with other in pain, more specifically left and right AI, ACC, lateral cerebellum and brainstem (Morrison et al., 2004; Singer et al., 2004).

Furthermore, both females and male recruit empathy-related activation in pain-related areas, more specifically fronto-insular and ACC, when observing fair players receiving pain. However, male exhibit a decrease in empathy-related responses when unfair players receive pain, not seen on females. Furthermore, increased activation in reward-related areas such as VS/NA, and left OFC, is observed in male but not females, when observing unfair players receive pain (Singer et al., 2006). Researcher argue their result can be interpreted as that empathic responses are shaped by valuation of other people’s social behaviour, but only in male, not in females. Moreover, SD in processes of pain was found, indicating that females showed stronger modulation by the task demands in the long-latency empathic response, in comparison to male (Han et al., 2008).

**Self-Other Awareness**

The next subcomponent of the model of empathy is self-other awareness, which as previous discussed, is the human ability to understand that self and other is similar but still separate starts to develop around the second year of life (Decety & Svetlova, 2012). Decety
and Jackson (2004) propose that the inferior parietal cortex in combination with the PFC together serve as critical structures in the sense of self by enabling discrimination of the source of sensory signals. Hence, the mentioned areas are crucial in the distinction between the self and others, and thus necessary for the experience of empathy. Furthermore, areas such as the frontopolar, the somatosensory cortex, and the right IPL has been argued to be crucial for the ability to distinguish between self and other (Ruby & Decety, 2004).

For more recent results, an fMRI study showed that by processing degrees of self-relatedness, the mPFC might sustain the process of identifying oneself with current representations of the self. Furthermore, the researchers propose that the right inferior parietal cortex might be engaged in distinguishing the present self from temporally distant selves (D’Argembeau et al., 2010). Moreover, from a meta-analysis of fMRI studies focusing on the role of the right temporo-parietal junction (TPJ), Decety and Lamm (2007) argue that the brain area of interest play a crucial role in both low-level and high-level cognitive functions.

Self-awareness seems to have similar cognitive processes as well as neural circuitry as the concept of ToM (Decety & Svetlova, 2012; Leslie, 1987), and therefore, SD will be reviewed under the subtitle ToM.

**Mental Flexibility**

Mental flexibility refers to the ability to adopt the subjective perspective of another person (Decety & Moriguchi, 2007), an effortful and controlled process that further serves as a crucial component in ToM (Decety & Jackson, 2004).

**Perspective taking.**

As previous stated, perspective taking is the human cognitive ability to adopt the subjective perspective of another person, an ability that requires both working memory and
inhibitory control (Decety et al., 2012).

Regions such as the posterior STS/TPJ, the temporal poles (TPs) and the mPFC has been considered to be involved in the processes of one thinking about the mental states of another person. Based on research in relation to each area, authors have theorized about how each region mentioned contributes in the mentalizing ability. While the mPFC is though to enable decoupling the mental state representations from physical state representations, the STS is hypothesized to enable detection of agence. The role of the TPs seems to be to contribute with social knowledge in the form of scripts (Frith & Frith, 2003). In line with this, a more recent fMRI study concludes that the mPFC are crucial in multiple forms of self-reflection (Jenskins & Mitchell, 2011). Moreover, and as previous mentioned, there are data serving evidence for that the MNS, more specifically the IFG are involved in emotional perspective taking (Schulte-Rüther et al., 2008).

Although the IFG are suggested as involved in emotional perspective taking in both females and males, activation in IFG and STS is stronger in females; suggesting females rely more on mirror neurons in assessing emotional states of other people and their own emotional response to the feelings of others. In contrast, males recruited increased activation in the TPJ in self-related emotional processing, suggesting they have a stronger recruitment of ToM related areas (taking (Schulte-Rüther et al., 2008.)

**Theory of Mind.**

As previous declared, ToM is a mentalizing ability enabling one to make implicit assumptions about the behaviours of other people based on one’s own desires, attitudes, and beliefs (Frith & Frith, 2003).

Drawn upon the facts available up to 2003, researchers concluded that the
mPFC, associated with different mentalizing tasks, are activated when people attend to certain states of the self or others. Furthermore, the researchers suggest that the TPs and the STS are structures involved in the ability to represent mental states of others (Frith & Frith, 2003). In a review article, authors conclude that the medial frontal cortex (mFC) play a special role in social cognition (Amodio, & Frith, 2006).

Other studies have not found support for the mPFC as essential in ToM, but rather proposed the right TPJ as selectively recruited for attribution of mental states (Saxe & Kanwisher, 2003; Saxe & Wexler, 2005). In her review article, Blakemore (2008) summarize with that both the mPFC, the ACC, the IFG, the STS, the amygdala and AI are brain areas that are involved in social cognitive processes, such as recognizing and evaluation mental states in other people.

With background in that it long has been hypothesized about that females and males differ in their mentalizing abilities, researcher conducted an fMRI study on 24 participants (12 females & 12 males), investigating the impact of sex and game partner (human vs. computer) on ToM and associated neural activity in mPFC (Krach et al., 2009). Researchers conclude that the medial frontal regions as well as TH regions were significantly more pronounced engaged in males compared to females (Krach et al., 2009).

In another fMRI study with 24 participants (12 females and 12 males) researchers found SD in the neural correlated underlying emotional perspective-taking (Derntl et al., 2010). Females particularly recruited IFG, the hippocampi, the superior temporal gyrus and the calcarine gyri as well as the right amygdala. In contrast, males showed stronger activation in areas such as TPJ. The researchers summarize with arguing their data supports the notion of females activate more emotion and self-related areas, whereas males recruit more cortical and cognitive-related regions.
As previous described, Baron-Cohen (2002) has proposed the E-S theory, more specifically arguing females are more empathizing with the motivation to identify emotions and thoughts of others, while male as more systemizing with a drive to gather information to draw predictions from. Moreover, Baron-Cohen (2002) has proposed the Extreme Male Brain (EMB) theory of autism, arguing that autistic children exhibit an extreme version of a typical male brain. Autism is a neurodevelopmental spectrum of conditions with subgroups such as classic autism and Asperger’s syndrome (AS) (Baron-Cohen, 2010). Children within this spectrum fail to normally develop their ability of social interaction, use their imagination and verbally and nonverbally communicate (Morrison, 1995). Children within this spectrum have delayed development of ToM, further argued as a type of mindblindness (Baron-Cohen, 1995).

In relation to SD, more boys than girls falls within the autism spectrum conditions (ASC)(Baron-Cohen, 2010). Furthermore, in ToM, girls develop ToM faster than do boys, and children within the ASC develop this ability even slower than do boys (Baron-Cohen, O’Riordan, Jones, Stone, & Plaisted, 1999). This pattern of females overall better than male in ToM, and furthermore people within the ASC below male in ToM, has been observed also in adult population, drawn upon data from the Reading the Mind in the Eyes Test (Baron-Cohen et al., 1997).

There is neuroscientific evidence supporting the EMB theory as well (Baron-Cohen, Knickmeyer, & Belmonte, 2005). Brain areas such as the ACC, superior temporal gyrus, PFC, and the TH are on average smaller in male than in females, and these regions are further even smaller in people within the ASC (Baron-Cohen et al., 2005). Furthermore, areas such as the amygdala, cerebellum, overall brain size/weight, as well as head circumference, that generally is greater in male than in females, are bigger in people within the ASC than in typical males (Baron-Cohen et al., 2005). In line with this data, as previous described, the SD
found in relation to the MNS during action observation with females’ greater mu suppression in comparison to males, served as indirect support the EMB theory (Cheng et al., 2008).

To summarize, brain areas such as mFC/mPFC, TPs, STS, as well as the TPJ has been argued as central to mentalizing tasks (Frith & Frith, 2003; Saxe & Kanwisher, 2003; Saxe & Wexler, 2005). Furthermore, areas such as ACC, IFG, STS, the amygdala and AI are also associated to social cognitive processes such as evaluating mental states in others (Blakemore, 2008).

In relation to SD, males recruit medial frontal regions and TH significantly more than do females in mentalizing tasks (Krach et al., 2009). In relation to emotional perspective-taking, males display stronger activation in TPJ, while females recruit IFG, hippocampi, superior temporal gyrus, the calcarine gyri and right amygdala (Derntl et al., 2010).

Furthermore, boys fall within the ASC more often than do girl (Baron-Cohen, 2010). Brain areas such as amygdala and cerebellum are generally greater in males than in females, and further even bigger in people within the ASC than in the typical male brain (Baron-Cohen et al., 2005).

**Regulatory Processes**

The ability to regulate one’s emotions refers to cognitive topdown-mechanisms that either aims at up-regulate or down-regulate emotions, and further increases the likelihood of experience empathy (Decety & Lamm, 2006; Eisenberg et al., 2004).

The ability to regulate one’s emotions, affect, drive and motivation lies on executive functions that are enabled through the dIPFC, ACC and the vmPFC through their mutually connections with the widespread cortical areas including the STS as well as the amygdala (Decety, 2011). For example, an fMRI study showed that the cognitive strategy of
volitionally regulating emotions was associated with activity in the medical prefrontal/anterior cingulate (AC) and the anterolateral PFC (Kalisch et al., 2005). Another fMRI study focused on both up- and down-regulation of negative emotions, with results showing that both up- and down-regulation of NE was associated with activation in prefrontal and AC regions (Ochsner et al., 2004). Furthermore, according to the regulatory goal, the activation in amygdala was changed. Moreover, up-regulation was specifically coupled to activation of left rostromedial PFC (associated with retrieval of emotional knowledge), while down-regulation activated orbital PFC (associated with inhibition of behaviour)(Ochsner et al., 2004). In line with this, Thompson (2011) argue that areas such as medial and ventral PFC as well as the AC, are all regions involved in emotion regulation.

With the aim to investigate SD in a cognitive emotion regulation strategy (reappraisal), researchers used fMRI on 25 participants (13 females and 12 males) while they were asked to down-regulate their emotional responses to negatively valence pictures (McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008). In comparison to males, females showed higher increases in the prefrontal regions associated with reappraisal, increases in the amygdala (associated emotional responding), as well as more engagement of ventral striatal regions (associated with reward processing).

Another study, used fMRI on 33 participants (16 females and 17 males) to investigate SD in emotional regulation with a delayed cognitive reappraisal paradigm (Domes et al., 2010). Results showed that females in comparison to males, when presented with aversive stimuli and asked to increase emotions, showed enhanced amygdala responding as well as an increased activity in small clusters within the PFC and the temporal cortex. While emotional reactions were decreased through cognitive strategies, females in comparison to males showed less activity in the OFC, the AC, and the dorsolateral PFC. When asked to cognitively increase emotional reactions, male showed an increase of regulatory cortical
areas, associated with an increase in amygdala activity (Domes et al., 2010).

To summarize, brain areas involved in regulatory processes of emotions are regions such as the PFC, ACC, STS, and amygdala (Decety, 2011; Kalisch et al., 2005; Thompson, 2011). Furthermore, amygdala activation is modulated in accord with regulatory goal, and activation in left rostromedial PFC is more associated with up-regulation, while activation in orbital PFC is more coupled to down-regulation (Ochsner et al., 2004).

SD has been observed in relation to down-regulation to negative pictures, with females recruiting prefrontal regions, amygdala, and the ventral striatal regions than do male (McRae et al., 2008). Furthermore, also in relation to down-regulation of aversive emotions, females show less activity in the OFC, the AC, and the dorsolateral PFC in comparison to male (Domes et al., 2010). When asked to increase emotions, females show enhanced activity in amygdala, PFC, and temporal cortex, while male show increase activity in cortical areas, associated with amygdala activity (Domes et al., 2010).

Neuroscientific SD in empathy has been reviewed, preceded by an overview of behavioural and psychological SD in empathy. So, where does the results come from and how to interpret this data?

**Potential Explanations**

Just as biology affects behaviour, so does behaviour affect biology. With basis in biological research, authors suggest that a more productive theoretical and empirical strategy to approach human behaviour is to recognize how social roles and biology together in an unseparatable way, are involved in the flexibility of the human behaviours (Taylor et al., 2000).

For example, gender roles have been considered as a potential explanation to SD
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observed. Chaplin and Aldao (2013) argue that SD is not something human children are born with. With background in that SD in positive, externalizing and general NE expressions were not evident in infancy, but rather did not emerge until toddler/preschool period and childhood, the authors suggest these emotion expressions as socialized. In relation to that girls displayed greater internalizing emotion expression already in infancy, in comparison to boys, the authors nevertheless argue that some emotion expressions could be innate or learned through socialization responses of care givers in a very early age (Chaplin, & Aldao, 2013).

Additionally, social desirability has been considered to contribute to the observed SD in empathy. From a study with the aim to test for SD in EC, researchers suggest that females in comparison to males are more susceptible to EC following brief interaction with a friend (Magen, & Konasewich, 2011). The researchers propose potential explanation for their results, suggesting factors such as social desirability, the possibility that females consider being an effective support is much more important than did males, and in line with the results, that females in comparison to males are more susceptible to EC (Magen & Konasewich, 2011).

Another perspective argues that SD observed in relation to empathy can be due to the specific measurement used. In a review article in 1983 (Eisenberg & Lennon, 1983), authors focused on SD in empathy and related capacities. With more specifically focus on emotional empathy, referring to “vicarious affective responding to the emotional state of another” (Eisenberg & Lennon, 1983, p. 100) authors argue that the observed SD were primarily due to the methods used to measure empathy. More specifically, females appeared more empathetic compared to males, when measuring empathy with self-report scales. This result was not visible in relation to neither physiological nor unobtrusive observations of nonverbal reactions to another persons’ emotional state. Females’ superiority in empathy in comparison to males
was observed but labelled as moderate, in relation to self-report measures in laboratory setting, and in regard to reflexive crying (Eisenberg & Lennon, 1983).

Although there are possibilities with different measurements, it also comes with potential restrictions in regard to analysis of results. Michalska et al. (2013) propose a potential explanation to those claimed theoretical and empirical SD observed in relation to empathy, meaning that rather than being due to actual SD, results could be explained by that different measurements focus of diverse components of empathy. Further, they argue it would be beneficial to focus on studies investigating diverse measures of empathy and also be able to understand the basis and nature of SD across indices.

Further, it has been argued for a potential bias in the literature on SD, more specifically meaning that journals are more likely to publish paper that do find SD than paper that do not. Moreover, this could consequently mean that researchers devote more effort in finding differences than to find no difference (Croson & Gneezy, 2009).

**Discussion**

The aim of this paper was to give an overview of behavioural, psychological and neuroscientific SD in empathy. Central findings including behavioural and psychological, as well as neuroscientific SD in empathy have been presented. In relation to behavioural and psychological SD, the central aspects have been emotion recognition, mentalizing abilities, pro-social behaviour. Regarding neuroscientific SD in empathy, central aspects have been affective sharing, self-other awareness, mental flexibility, and regulatory processes.

Starting with ER, there is evidence for superiority in females of multisensory processing of emotion expression (Collignon et al., 2010). However, there is evidence for that SD has been more observed in relation to NE than in relation to PE (Steven & Hamann, 2012). Hence, this might contribute with a restriction in interpreting the data from the study focusing on multisensory processing of emotion expressions, where researchers only used
either disgusted or fearful facial expressions (Collignon et al., 2010). Although, evidence for that females are both better and faster in ER in both PE and NE facial expressions is still evident (Hampson et al., 2006). Furthermore, females compared to males are both more accurate and sensitive in labelling facial expressions (Montagne et al., 2005), better able to recognize subtle emotional expressions (Hoffman et al., 2010), regardless of the sex of the person displaying the emotion (Thayer & Johnsen, 2000). Moreover, in relation to body recognition, females seems superior in PLD perception tasks in bodily ER and bodily action recognition (Alaerts et al., 2011), with females more accurate rather than faster than males (Sokolov et al., 2011). The trend of female’s superiority in ER goes further beyond conscious awareness, with females better at recognize positive valence of facial emotions, an effect not found in males (Donges et al., 2012). In line with this, females in comparison to males also show enhanced emotional processing from tone of voice in a preconscious stage of processing (Schirmer et al., 2005). Moreover, mood affects males with happy mood meaning better ER, which was not found in females (Schmid et al., 2011). Overall, support for SD in ER was found, more specifically pointing towards a female’s superiority in comparison to males.

In relation to ToM, both girl/females in comparison to boys/males have been found to be better performers in different ToM-tests (Baron-Cohen et al., 1997; Walker, 2005). Nevertheless, there are inconsistent findings with results indicating no SD (Jarrold et al., 2000), as well as male superiority in ToM (Russel et al., 2007). With SD evident in both children and adults in relation to ToM (Baron-Cohen, Joliffe, Mortimore, & Robertson, 1997; Walker, 2005), one might argue that gender roles may not explain these results, unless gender roles are learned in very early childhood. Furthermore, the study conducted by Walker (2005), with the aim to test relationship between ToM and peer-related social competence, the ones rating the children’s peer-related social behaviour were their teachers, not the children
themselves. When teachers are rating children’s behaviour, gender roles could be a contributor to the results.

In relation to pro-social behaviour, evidence suggests that females are more cooperative than males (Eckel & Grossman, 2001). However, contextual factors such as sex of the respondent might affect the subject’s behaviour (Eckel & Grossman, 2001), potentially through both gender roles and social desirability. This might further be a contributor to that females are more able to give money as well as volunteer more hours than do males, especially given the author’s concluding remarks that females in relationship with males seem to socialize males in relation to philanthropic giving (Mesch et al., 2006).

Continuing to neuroscientific SD, the existence of SD in neuroanatomy is evident, showing females exhibit greater GM volumes in cingulate cortex (Good et al., 2001), the right IFG, in pars opercularis as well as in IPL (Cheng et al., 2009), and in parts of mPFC (Yamasue et al., 2008). Males have higher percentage of WM and CSF (Gur et al., 1999). Amygdala and cerebellum is larger in males (Cheng et al., 2009).

Regarding affective sharing, in relation to the MNS, females in comparison to males have greater GM in pars opercularis and IPL of RH, areas involved in the MNS (Cheng, et al., 2009). Further, females in comparison to males seem to recruit mirror neurons to a greater extent when watching hand movements (Cheng et al., 2008). Hence, both neuroanatomical and functional SD is found in relation to mirror neurons. Nevertheless, there is a controversy about the existence of mirror neurons. Some researchers argue that the properties of mirror neurons map well onto emotion contagion, as well as argue that most studies support the notion of existence of mirror neurons from that findings of activation of brain networks involved in first hand experience also activates when observing affective state in others (Bernhardt & Singer, 2012; Iacoboni, 2011). Although, other researchers argue that
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the existence of mirror neurons in humans lack direct empirical support, where they among other things refer to that fMRI cannot give such good spatial resolution. Furthermore, it has been argued that even though mirror neurons would exist in humans, it would not necessarily mean that mirror neurons underlie empathy (Lamm & Majdandzic, 2014). Because of this controversy regarding mirror neurons, the author suggests careful interpretations of the findings presented.

In relation to EC, both amygdala and STS are crucial for social perception (Allison et al., 2000; Haxby et al., 2002; Shaw et al., 2005). In relation to emotion memory, females use significantly fewer brain areas including amygdala, while males use more structures including right amygdala (Canli et al., 2003). Amygdala gets more activated in both sexes when observing faces versus bodily expression, especially in males observing female faces (Kret et al., 2012), potentially reflecting males bigger amygdala (Cheng et al., 2009). Further, increased activity in STS is more coupled to threatening bodies versus faces, also this specifically in males. Existence of SD in relation to EC is evident, although depending on contextual cues such as the sex of the one displaying emotion, as well as if it is a body or face showing emotions (Kret et al., 2011), factors that potentially could get affected by gender roles. Further, empathize with others in pain can elicit activity in AI, ACC, cerebellum and the brainstem (Morrison et al., 2004; Singer et al., 2004). Although, social relation affect the emotional and bodily experience of empathizing, indicating that seeing fair players in pain activated AI and brainstem in both sexes, although the effects was greater in females. In contrast, unfair players perceiving pain decreased empathy-related activity to a small degree in females, but significantly in males (Singer et al., 2006). Further, increased activation in NA, a suggested reward-processing area, was observed in males when observing unfair player receive pain (Singer et al., 2006). This could potentially have evolutionary roots, referring to the origin of empathy in care giving and group living (Decety, 2015).
Continuing, areas such as mPFC, STS, TPJ, IFG, and TPs is central in different mentalizing tasks such as perspective-taking and ToM (Amodio & Frith, 2006; Frith & Frith, 2003; Jenskins & Mitchell, 2011; Saxe & Kanwisher, 2003; Schulte-Rüther et al., 2008). Females show stronger activity in IFG and STS, while males show increased activity in TPJ (Schulte-Rüther et al., 2008). Similar results has been showed, adding calcarine gyri and amygdala to structures activated more in females than in males (Derntl et al., 2010). In relation to ToM, medial frontal regions and TH are more engaged in males than in females (Krach et al., 2009). Furthermore, in relation to ToM and ASC, a disorder more prevalent in boys than in girls (Baron-Cohen, 2010), there is evidence for that areas such as PFC, superior temporal gyrus, ACC, and TH, often smaller in boys than girls, are even smaller in children within the ASC than in boys (Baron-Cohen et al., 2005). As mentioned in relation to neuroanatomical SD, the amygdala and cerebellum is greater in males than in females (Cheng et al., 2009). Children within the ASC exhibit greater amygdala and cerebellum as well (Baron-Cohen et al., 2005).

Continuing with regulatory processes, showing that PFC and AC, with their connections to cortical areas, including STS and amygdala, have been coupled to emotion regulation (Decety, 2011; Kalisch et al., 2005). Down-regulating NE activates PFC, amygdala, and ventral striatal regions, more in females than in males (McRae et al., 2008). When asked to increase emotions in relation to aversive stimuli, females in comparison to males showed increased activity mainly in amygdala, but also in PFC and temporal cortex. Under same conditions, males showed increased amygdala activity (Domes et al., 2010).

From the research reviewed, there is evidence supporting both behavioural, psychological and neuroscientific SD in empathy, although inconsistencies have been presented regarding behavioural SD in ToM and pro-social behaviour. From what the author
has presented, one could further argue that the most extensive support for SD in empathy seems to be regarding emotion processing.

So what are the implications of these findings? First of all, there is a restricted amount of research in relation to behavioural and neuroscientific SD in empathy. Further, the studies that do exist, present inconsistent findings. Moreover, in relation to some of the concepts, e.g. mirror neurons, there is a controversy about actual existence of these specific neurons in humans, which make results difficult to interpret. Furthermore, SD in empathy is controversial, and even when leaving the perspective of SD out, the research field with focus on the broad perspective of empathy has also been criticized (Michalska et al., 2013). More specifically, empathy research has been accused for being too artificial in their settings, resulting in simplification of social cues, models of empathy etc. Further, empathy research has been argued to lack connection between neuroscientific and behavioural research fields, consequently leading to an imprecision in terminology (Zaki & Ochsner, 2012). Because of these controversies about central concepts, the criticism regarding how the research field approach the concept of empathy, as well as the controversial aspects of sex differences as well as the inconsistent findings; this cause the author to argue that one should approach these findings presented with great caution, being aware of difficulties in interpreting the data.

**Conclusion**

The aim of this paper was to give an overview of behavioural, psychological and neuroscientific sex differences in empathy. With evolutionary basis in caregiving (Preston & de Waal, 2002), and group living (Decety, 2015), empathy enables sharing of information of intentions and emotions, as well as contributes with the capacity to appropriately respond to that information (Decety et al., 2012). Although there is no general agreement of defining empathy, most researchers agree that empathy consists of both emotional and cognitive
components (e.g. Baron-Cohen & Wheelwright, 2004; Berglund & Annett, in press; Decety & Jackson, 2004; Shamay-Tsoory, Aharon-Peretz, & Perry, 2009).

Behavioural and psychological sex differences in empathy were presented, with research findings supporting females’ superiority in emotion recognition (Anders & Mullin, 2006; Donges et al., 2012; Montagne et al., 2005; Sokolov et al., 2011). In relation to sex differences in both theory of mind and pro-social behaviour, inconsistent findings was presented (Baron-Cohen et al., 1997; Eckel & Grossman, 2001; Mesch et al., 2006; Russel et al., 2007; Solnick, 2001).

Moving on, neuroscientific sex differences in empathy was presented, based on Decety and colleague’s model of empathy (Decety & Jackson, 2004; Decety & Moriguchi, 2007), starting with an overview of neuroanatomical sex differences. Both neuroanatomical and functional sex differences were found in relation to the mirror neuron system, emotion contagion, as well as in relation to pain research (Canli et al., 2003; Cheng et al., 2008; Cheng et al., 2009; Kret et al., 2011; Singer et al., 2006). Research indicating existence of sex differences in relation to perspective-taking, theory of mind, as well as regulatory processes was presented (Baron-Cohen et al., 2005; Chulte-Rüter et al., 2008; Derntl et al., 2010; Domes et al., 2010; Krach et al., 2009; McRae et al., 2008).

Potential explanations to observed sex differences in empathy were presented, including factors such as gender roles, social desirability and limitations of measurements. These factors were further discussed in relation to the behavioural, psychological and neuroscientific research findings of sex differences in empathy presented.

To conclude; sex differences was found in relation to both affective and cognitive components of empathy, However, there is still both a restricted amount of research available as well as inconsistent findings. Furthermore, with controversies regarding main
concepts related to empathy, with for example proposed central neural mechanisms such as mirror neurons, there is a great limitation in how to interpret the findings.

For future research, clear and agreed definitions of subcomponents of empathy with consistent terminology between behavioural and neuroscientific research fields, could contribute to a solid foundation for empathy research to stand on. To refer to the beginning of this paper, it has been proposed that social cognition is an important component of mental health, and hence therefore important to investigate sex differences in the neural mechanisms underlying empathy (Christov-Moore et al., 2014). However, with empathy as an uncertain and controversial concept, turning to investigating sex differences in empathy could be considered not to be relevant until the research field has a common picture of what empathy is and what neural mechanisms enable empathy.
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### Appendix

Table 1

*Most recurring abbreviations used in the paper*

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<thead>
<tr>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>ACC</td>
<td>Anterior cingulate cortex</td>
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<td>AI</td>
<td>Anterior insula</td>
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<tr>
<td>FI</td>
<td>Fronto-insular</td>
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<td>IFG</td>
<td>Inferior frontal gyrus</td>
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<td>IPL</td>
<td>Inferior parietal lobule</td>
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<td>MNS</td>
<td>Mirror Neuron System</td>
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<td>NA</td>
<td>Nucleus accumbens</td>
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<td>NE</td>
<td>Negative emotions</td>
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<td>OFC</td>
<td>Orbitofrontal cortex</td>
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<td>PE</td>
<td>Positive emotions</td>
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<td>PDG</td>
<td>Prisoner’s Dilemma Game</td>
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<tr>
<td>PFC</td>
<td>Prefrontal cortex</td>
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<td>PMC</td>
<td>Premotor cortex</td>
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<td>SD</td>
<td>Sex differences</td>
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<td>STS</td>
<td>Superior temporal sulcus</td>
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<td>TH</td>
<td>Thalamus</td>
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<td>TPJ</td>
<td>Temporo-parietal junction</td>
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<tr>
<td>VS</td>
<td>Ventral striatum</td>
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