WHEN BODIES BECOME OBJECTS AND OBJECTS COME TO LIFE

WHEN BODIES BECOME OBJECTS AND OBJECTS COME TO LIFE: SPECIALIZED PROCESSING FOR SOCIAL STIMULI AND THE DEVELOPMENT OF ANIMACY DETECTION

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TITLE: When bodies become objects and objects come to life: specialized processing for social stimuli and the development of animacy detection

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Lay abstract

Humans rely on other people for social interaction and cooperation. We allocate attention and gaze to social agents, and our visual system processes social stimuli in qualitatively different ways compared to objects. Across three studies, we examined the ability to differentiate between social and non-social stimuli and specialized social processing. In the first study, we investigated in which contexts bodies are processed by the visual system as objects rather than social stimuli. The more sexualized targets are, the more likely they are to be processed as objects. Our second study showed that infants, like adults, prioritize attention toward humans or animals compared to objects. Eleven-month-olds are more adept at detecting the removal of humans or animals compared to objects from an image of a natural scene. In our final study, we tested 4-year-olds' ability to detect chasing motion. Children can quickly pick out a chasing agent among random motion.

Abstract

Humans are social beings. They quickly detect other agents such as people or animals, preferentially attend to them (New, Cosmides, & Tooby, 2007), and process social stimuli differently than non-social objects (Reed, Stone, Bozova, & Tanaka, 2003; Yin, 1969). Three studies focused on the ability to differentiate between social and non-social stimuli and on specialized social processing. Chapter two showed that female bodies are perceptually objectified, leading the visual system to process them as objects. However, this effect can be manipulated by providing high or low sexualizing information about a target. Results indicated that body images paired with high sexualizing information are more likely to be perceptually objectified, regardless of whether they are male or female targets. Chapter three showed that infants, like adults, prioritize attention to social stimuli. We used an adapted change detection paradigm to test whether 11-month-olds would be better able to detect changes to animate or inanimate entities. Results indicated that infants are more likely to notice changes to animate entities. Chapter four reports a test of 4-year-old children's ability to detect a chasing agent among increasing numbers of distractors. Participants were presented with moving displays of a chasing agent and its target, surrounded by up to 10 distractors. Children were asked to identify the chaser by touching it on the screen. Our results showed that 4-year-old children show a pop-out effect for chasing motion. Reaction time to identify the chaser was independent of how many distractors were added to the display. Overall, our studies suggest that, from

infancy onward, humans orient towards social information and process it differently than inanimate objects. Further, the context can significantly impact how stimuli are viewed.

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Abbreviations and Symbols

2AFC, two-alternative forced-choice

adj. R^2, adjusted coefficient of determination

ANOVA, analysis of variance

AOI, areas of interest

CI, confidence interval

cm, centimetre

d, Cohen's d

df, degrees of freedom

EEG, electroencephalographic

F, F-ratio

Hz, hertz

M, mean

MS, millisecond

p, p-value, probability

ppf, pixels per frame

RMS, root mean square

RT, reaction time

SBIH, Sexualized Body Inversion Hypothesis

SD, standard deviation

SE, standard error

t, t statistic

Declaration of Academic Achievement

Chapter 2: Dr. Mel Rutherford and I conceptualized and designed both studies and I programmed the experiments. Philippe Bernard shared his image set with us and a female undergraduate research assistant recorded the audio clips. I ran the majority of the participants with assistance from undergraduate students in the lab. Matt Pachai performed the ideal observer analysis and helped me interpret the results. I performed all other analyses and generated all figures. I wrote the paper and Dr. Mel Rutherford and I jointly edited it into its final form.

Chapter 3: Dr. Mel Rutherford and I conceptualized and designed the study and I programmed the experiment. I ran the participants with assistance from a thesis student and undergraduate volunteers in the lab. I performed all analyses and generated all figures. I wrote the paper and Dr. Mel Rutherford and I jointly edited it into its final form.

Chapter 4: Dr. Mel Rutherford and I conceptualized and designed the study and I programmed the experiment. I ran the participants with assistance from undergraduate students in the lab. I performed all analyses and generated all figures. I wrote the paper and Dr. Mel Rutherford and I jointly edited it into its final form.

I generated all other materials with final editorial comments provided by my committee: Dr. Bruce Milliken, Dr. Sukhvinder Obhi, and Dr. Mel Rutherford.

Chapter 1: Introduction

The complexity of human social perception and social cognition sets them apart from all other species. We quickly orient towards social agents in our surroundings and filter out irrelevant non-social information. Social perception is automatic, and we are unaware of how many cognitive and perceptual processes are at work when we interact with other people or simply look at them. Social cognitive skills like imitation, joint attention, and animacy perception enable us to form rich complex relationships. Humans use spoken and written language to pass on new ideas, materials and technologies over generations, resulting in cumulative culture. Cumulative culture allows us to modify and innovate upon knowledge and skills over time. This social type of learning which is unparalleled in sophistication has allowed humans to become the most wide-spread mammal on earth, occupying numerous climates from arid deserts to the artic tundra.

Humans are social animals

According to the social brain hypothesis, humans have evolved to possess such large brains, in particular a large neocortex, because they were faced with navigating social conflicts and challenges (Barton & Dunbar, 1997; Brothers, 1990; Dunbar, 1993). Consistent with this view, group size is correlated with neocortex size among primates (Aiello & Dunbar, 1993; Dunbar, 1993; Kudo & Dunbar, 2001). Non-human primates live in groups of 50 individuals at most and use social grooming or food sharing to maintain relationships among group members (Kudo & Dunbar, 2001; Muller & Mitani, 2005). Humans, on the other hand, form social groups with up to 150-200 people. It is impossible to cultivate relationships with that many people through social grooming or in-person interactions. Dunbar (1993) suggested that language enables humans to bond with one another and maintain relationships, without being as time-consuming as social grooming. We interact with our social partners daily, whether in person, talking over the phone or in writing. We feel a need to connect with others and to fit in (Gardner et al., 2000).

Humans are not the only animals to live in groups (Deneubourg, & Pasteels, 1989; Kudo & Dunbar, 2001; Ward, Webster, Magurran, Currie, & Krause, 2009). While some animals, like sheep and fish, primarily live in groups as protection from predators, humans form complex social relationships with individuals within their group. This complex social context created selection pressures for social cognition and social perception.

Other theories suggest that humans' large brains are not only a result of social requirements but due to high behavioural flexibility (Barrett & Henzi, 2005) Throughout evolution, humans needed to respond to complex social demands as well as adapt to changing environmental conditions. These challenges and interactions between social and environmental factors have been argued to have led to the development of large brains (Sterelny, 2007)

Typical development requires social interaction

Starting around 2 months of age, children engage in reciprocal interactions with their parents, such as social smiling, affect mirroring and mutual imitation

(Messinger & Fogel, 2007; Rochat, 2007). A child whose parents are responsive will learn that if the child smiles, the parents will smile back. Through these reciprocal exchanges, the child learns that his or her actions result in effects and that they are an active agent (Rochat, 2007). Critically, children reared in orphanages, who are deprived of social interaction, learn that crying does not lead to a response and eventually stop (Chisholm, Carter, Ames, & Morison, 1995). While orphans do develop social skills and a sense of agency, they are at higher risk for self-esteem problems (Erango & Ayka, 2015; Farooqi & Intezar, 2009). Therefore, it seems that social interaction plays a crucial role in the typical development of a child’s sense of agency (Tomasello, 1999).

Imitation is one of the earliest forms of social interaction in which a child can actively engage. After seeing their parents stick out their tongue, newborn infants who are only a few days old can imitate this simple action (Meltzoff & Moore, 1983, 1989). Through interaction with their caregiver, infants also learn to respond to their name. By 4 months of age, they recognize their own name (Parise, Friederici, & Striano, 2010). For the first 9 months, infants exclusively engage in one-on-one interactions. However, at the 9-month mark, infants develop an ability to engage with a social partner while also attending to another person or object. This qualitative shift in social cognition has been called the nine month revolution (Tomasello, 1999). Following the nine month revolution, children demonstrate skills like gaze following, pointing , and joint attention (Corkum & Moore, 1998). Infants come to understand that both gaze direction and pointing imply intention and try to figure out what the other person is attending to (Leung & Rheingold, 1981; Senju & Csibra, 2008). Joint attention refers to the ability to tell when a child is attending to an object on which their social partner is also focused. It allows for the child and social partner to communicate about the shared object of attention (Striano & Rochat, 1999). All of these social skills develop over the first year of life and continuous social interaction is required for their development.

Social interaction also plays a key role in a child's emotional development. As a newborn, infants rely exclusively on their caregivers to regulate their arousal. Throughout childhood, parents help their child understand and regulate their own emotions by modeling, responding to the child's behaviour and emotions appropriately and teaching them how to self-regulate (Calkins, 1994; Frankel et al., 2012). As children become mobile and begin to actively engage with their environment, they use their parents as a reference point. When 12-month-olds were confronted with a novel stimulus, children looked to their parent for guidance on how to react. This process is called social referencing. If the parent displayed fear towards a novel object, children were less likely to approach it (Mumme, Fernald, & Herrera, 1996). Learning how to appropriately react to new situations and the ability to regulate one's emotions are vital to positive social interactions (Lougheed & Hollenstein, 2012; Rubin, Coplan, Fox, & Calkins, 1995).

Social interaction is imperative to survival

Humans do not only enjoy human interaction, but they require it. Compared to other species, human babies are born premature, rendering them helpless and heavily dependent on their caregiver (Dunsworth & Eccleston, 2015). Infantile features, including protruding cheeks and large eyes, draw adults to infants and ensure parents' willingness to provide for their children and interact with them.

This social dependency does not cease once children gain more autonomy, rather, a need for social interaction persists throughout life. When people feel left out and isolated from others, severe negative consequences follow. Perceived social isolation in adults is associated with poor overall cognitive performance, increased negativity and depressive cognition. It increases an individual's sensitivity toward social threat and this shift in cognition and attention affects emotions, decision making and interpersonal interactions (Cacioppo & Hawkley, 2009). Social isolation is stressful as indicated by rises in cortisol and blood pressure and poorer sleep (Cacioppo, Hawkley, Norman, & Berntson, 2011). In contrast, the more we identify with others, the more strongly we empathize with them (Krebs, 1975).

Empathy is the capacity to infer and feel what another person is feeling. It involves affective congruence, perspective-taking, and prosocial motivation (Morelli, Rameson, & Lieberman, 2014). Seeing others in distress and empathizing with them is distressing, resulting in cardiac reactivity (Sze, Gyurak, Goodkind, & Levenson, 2012). Humans show empathy towards others for both positive and negative affect, such as happiness or anxiety (Morelli et al., 2014). Empathy is linked to positive relationships with others and helping (Grühn, Rebucal, Diehl, Lumley, & Labouvie-Vief, 2008; Krebs, 1975; Sze et al., 2012).

The costs and benefits of cooperation

Although human cooperation is unparalleled in complexity and effectiveness, cooperation is common across many species (Beckers, Goss, Deneubourg, & Pasteels, 1989; Tomasello, 2009; Wilkinson, Carter, Bohn, & Adams, 2016). Insects, like ants, bees and wasps, share responsibilities like collecting food and defending their colony against predators. Some members of the group do not reproduce and instead take on collective brood care (Beckers et al., 1989). Bats cooperate to forage by communicating prey location to one another and work together to feed and care for offspring within their roost. Cooperation in bats is not limited to relatives but extends to non-kin (Wilkinson et al., 2016). Chimpanzees have also been shown to cooperate, sharing food and grooming one another (Muller & Mitani, 2005). They even show some helping behaviour across species (Warneken, Hare, Melis, Hanus, & Tomasello, 2007).

Humans cooperate on a larger scale than most other animals. In human societies, there is a division of labour. Individuals take on specialized occupations and depend on one another to trade goods and services. Skills and information can be passed on both through personal interactions and over time in writing (Boyd & Richerson, 2009; Dunbar, 1993). This cultural transmission of passing on complex knowledge over generations is uniquely human (Tomasello, 2009).

There are obvious benefits to cooperation when it is reciprocal. However, humans also help others when doing so costs them (Trivers, 1971). Historically, evolutionary theorists struggled to explain altruistic acts (Darwin, 1872). Hamilton suggested that altruism can be beneficial if the cost to an individual is outweighed by the benefit that a genetic relative receives, even if the relative is not a direct offspring. According to Hamilton's rule, how high of a cost an individual is willing to incur should depend on how closely they are related to the recipient (Hamilton, 1963, 1964).

However, we also regularly help non-kin at a cost to ourselves. Gardner and West (2004) proposed that the threat of punishment could potentially fill this gap. Altruism and cooperation are not only costly, but they also require members of a group to be vigilant for cheaters (Cosmides, 1989). Every individual tends to have altruistic and cheating tendencies but behaviours are policed by the group (Trivers, 1971). If a member of a group is trying to freeload, it would be adaptive for other members of the group to punish their behaviour. Punishment is costly to the actor and the recipient. However, the cost to the punishing actor is lower than the resulting benefit of increased cooperation. Therefore, it is worth the investment. Individuals who have been punished previously will cooperate to avoid future punishment (Gardner & West, 2004). Cooperation with non-kin can also be explained through a shared interest in cooperation. An individual might be willing to help in hopes of being included in a group that will provide protection against predators at a later point (West, Griffin, & Gardner, 2007).

Development of empathy and prosocial helping behaviour

Young children already show concern for others and empathize with them which increases their tendency to help others (Williams, O'Driscoll, & Moore, 2014). Even newborn infants will cry in response to hearing another baby cry. This response has been interpreted as a precursor of empathy. Newborn infants only have a basic sense of self-awareness and cannot yet distinguish between the distress of others and their own discomfort (Rochat & Hespos, 1997; Sagi & Hoffman, 1976). Around 6 months of age, children start to show a preference for prosocial versus antisocial agents (Hamlin & Wynn, 2011; Hamlin, Wynn, & Bloom, 2007). Empathy and concern for others within in the first year predict prosocial behaviour in the second year of life (Roth-Hanania, Davidov, & Zahn-Waxler, 2011). Within the second year of life, children also form expectations about sharing and fairness and want people who are distressed to receive help (Hepach, Vaish, & Tomasello, 2012; Sommerville, Schmidt, Yun, & Burns, 2013). Young children do not only expect others to help but are willing to offer help themselves. Warneken and Tomasello (2007) found that, as early as 14 months of age, children will readily help another person complete a task, even if the child does not directly benefit. Children would watch an experimenter try to perform a task and fail to do so. For example, the experimenter would try to hang towels on a clothing line and accidentally drop the clothespin. Children successfully inferred the experimenter's intention and helped them reach their goal by picking up the clothespin and handing it to them (Warneken & Tomasello, 2007).

Children seem to enjoy collaborating with others and show little interest in trying to freeload (Gräfenhain, Behne, Carpenter, & Tomasello, 2009).. Eighteen-month-olds who saw someone else harmed expressed concern through facial expressions and subsequently showed more prosocial behaviour towards the person who had been harmed (Vaish, Carpenter, & Tomasello, 2009). Further, young children who saw someone else in distress were equally as satisfied whether they themselves helped the person or someone else did. Children's goal is not necessarily to help but to see distress relieved (Hepach et al., 2012). This prosocial attitude emerges early in life, persists throughout childhood and is seen across cultures (Blake et al., 2015). Humans are not the only species to cooperate (Beckers et al., 1989; Wilkinson et al., 2016) and, like infants, chimpanzees show an ability to infer people's goals (Warneken et al., 2007). However, there are some aspects of human social cognition that seem to be unique (Call & Tomasello, 2008; Marticorena, Ruiz, Mukerji, Goddu, & Santos, 2011).

Specialized mechanisms for the visual perception of social stimuli

Social stimuli, like faces and bodies, are rich sources of information and such stimuli are processed by specialized mechanisms in the brain. Evidence for this claim of specialized processing comes from the inversion literature (Freire, Lee, & Symons, 2000; Maurer, Le Grand, & Mondloch, 2002; Reed et al., 2003; Yin, 1969). Faces and bodies have been argued to be processed configurally. This means that the configuration of features within the face matters and we always expect the configuration to stay the same. Eyes should always be located above the nose, and the nose above the mouth. Inanimate objects, on the other hand, are processed featurally. When looking at a car, we pay attention to and process individual features, such as the headlights or a window, and process them in isolation rather than their configuration to one another. The inversion effect occurs when images of social or non-social stimuli are turned upside down, rotated by 180 degrees. Turning the image upside down, disrupts the configuration of features and thereby significantly impairs visual processing of social stimuli. While humans are very efficient at processing faces and bodies when they are presented in upright orientation (Crouzet, Kirchner, & Thorpe, 2010; Hershler & Hochstein, 2005), they struggle to process these stimuli when they are inverted. Processing of non-social stimuli remains unaffected (Freire et al., 2000; Maurer et al., 2002; Reed et al., 2003; Yin, 1969). This suggests that social stimuli are processed qualitatively differently than non-social stimuli.Looking at a face generates a qualitatively different brain response than looking at other stimuli (Caharel & Rossion, 2016). Further, facial recognition begins as early as 100ms, while activation for other objects does not start until 200ms (Pegna, Khateb, Michel, & Landis, 2004).

When watching others perform an action, some of thesame neural systems are activated as if we were performing the action ourselves. Our brain is mirroring the observed action. Mirroring helps us analyze and predict the actions and intentions of others (Frith & Frith, 2001; Gallese, 2005). Woodward and Cannon (2013) suggested that as children learn to perform new actions, they store motor representations of them. They can then draw on these representations to anticipate other agents' movements when performing similar actions (Falck-Ytter, Gredebäck, & von Hofsten, 2006). When 9-month-olds were shown the beginning of an action, electroencephalographic (EEG) signals, specifically attenuating of the sensorimotor alpha signal, indicated motor system activity (Southgate, Johnson, Karoui, & Csibra, 2010). Even though children were simply watching and not performing motor actions themselves, similar motor system activation was found as if they were. Importantly though, if infants were unable to predict the outcome of an event, mirroring did not occur (Southgate et al., 2010). It seems that at this age, mirroring depends on infants' ability to infer a goal.

Preferential attention to social stimuli and animate agents

Humans orient towards other social agents. Attention and gaze are allocated depending on how much a stimulus stands out among other stimuli. This is particularly true for first fixations, immediately following stimulus onset (Parkhurst, Law, & Niebur, 2002). Attention-grabbing stimuli can trigger gaze shifts, even if a stimulus is task irrelevant, and this effect can vary depending on an individual's current drives and individual differences (Lachter, Forster, & Ruthruff, 2004). Anxious individuals spend more time looking at threat related items than non-anxious individuals and depressed individuals show less orienting and shorter fixations to positive stimuli than non-depressed individuals

(Armstrong & Olatunji, 2012). Previous research investigating attention to faces and bodies has shown that search times for human faces among distractors are independent of set size which is evidence of a pop-out effect. Regardless how many distractors are present, the face stands out amongst them (Hershler & Hochstein, 2005).

Humans scan their environment for social agents and are incredibly adept at distinguishing between animate, living, agents and inanimate, non-living, objects. Adult participants are both accurate and fast at detecting social stimuli, such as people or animals, and saccades towards animate stimuli are initiated as quickly as 120ms which is significantly faster than for inanimate entities (Crouzet, Kirchner, & Thorpe, 2010; Kirchner & Thorpe, 2006; New, Cosmides, & Tooby, 2007). Detection rates for inanimate targets are significantly slower than those for animate targets. Detection latencies for inanimate objects increase even more when an animate object is present within the same displays, as attention is likely redirected to the animate object (Altman, Khislavsky, Coverdale, & Gilger, 2016). Not only are social stimuli detected faster but our episodic memory also shows superior recollection of information related to animacy (Nairne, VanArsdall, & Cogdill, 2017). New, Cosmides and Tooby (2007) argued that this detection advantage for social stimuli is an evolved adaptation and arises from preferential attention towards animacy. From an evolutionary perspective, it is adaptive for our attention system to be guided by animacy, allowing us to quickly process animacy cues, particularly those that indicate threat (Eastwood, Smilek, & Merikle, 2001; LoBue, 2010; Öhman, Flykt, & Esteves, 2001).

Even new born infants orient towards social agents and show a preference for faces over other stimuli (Fantz, 1963; Valenza, Simion, Cassia, & Umiltà, 1996). This face preference persists throughout infancy (Mondloch et al., 1999). As infants are highly dependent on their caregiver, it makes sense that they would try to locate agents in their environment. Like adults, school-aged children have been shown to be fast and efficient at processing faces (Freire & Lee, 2001).

Animacy detection is irresistible

In addition to physical appearance, humans use motion cues to pick out animate agents in their environment and distinguish them from inanimate entities. Adults do not only ascribe agency to humans and animals but also to geometric shapes that move as if they were alive (Heider & Simmel, 1944; Tremoulet & Feldman, 2000). When adult participants are shown geometric shapes moving on a computer screen, interacting with one another, participants use anthropomorphic terms to describe them and seem to be unable to define the movements in strictly physical ways (Rochat & Hespos, 1997; Scholl & Gao, 2013)

Point light walkers evoke perceptions of animacy and intentionality (Elsner, Falck-Ytter, & Gredebäck, 2012). Point light walkers are comprised of coordinated moving dots with each dot representing a human joint. The glowing, moving lights shown on a dark background are a simplistic representation of a human body in motion. Various studies have investigated motion cues using point light walkers (Elsner et al., 2012; Troje & Westhoff, 2006). When we watch another person perform an action, we anticipate the outcome of the action and shift our gaze towards the goal object. Elsner, Falck-Ytter, and Gredebäck (2012) found that if point light walkers move in a way that is consistent with real-life biological velocity and motion, participants can infer the goal of an action and show anticipatory gaze. However, if point light walkers move in an unnatural, non-biological way, there is not anticipatory gaze. Despite how simplistic these displays are, the perceptions they evoke are powerful.

How is it adaptive to ascribe animacy to geometric shapes or moving dots on a computer screen when we are consciously aware that these objects are not alive (Heider & Simmel, 1944; Scholl & Gao, 2013)? In the environment in which our species evolved, fast detection of animate entities could have meant life or death (New et al., 2007a). Animate agents could have been members of an outside group, trying to invade, or potential predators, such as wild animals, about to attack. Therefore, the cost of a false positive detection of animacy would have been lower than missing the presence of a predator (Haselton & Buss, 2000). As a result, our attention system seems to have evolved to show increased sensitivity towards potential threat, leading to an irresistible and automatic attribution of animacy (Scholl & Gao, 2013; Simion, Bardi, Mascalzoni & Regolin, 2013). Adults are better at detecting the presence of animate motion than determining that animate motion is absent (Meyerhoff, Schwan, & Huff, 2014b). Cues indicative of a chase or attack, such as smaller inter-object spacing and orientation of objects towards their target, attract attention (Gao, McCarthy, & Scholl, 2010; Meyerhoff, Schwan, & Huff, 2014a). Further, potentially threatening stimuli such as negative faces (Eastwood, Smilek, & Merikle, 2001) or images of snakes or spiders (Öhman, Flykt, & Esteves, 2001) are more effective at modulating attention than positive or neutral stimuli.

Development of animacy detection

Like adults, children are interested in animate motion from infancy onwards (Crichton & Lange-Küttner, 1999; Frankenhuis, House, Barrett, & Johnson, 2013; Rochat, Morgan, & Carpenter, 1997a). As early as 3 months of age, infants can distinguish between animate and inanimate motion and show a looking preference for animate motion (Rochat et al., 1997). Around 8-10 months of age, children begin to understand social contingencies underlying interactions. When they see a dot on a computer screen chasing another dot, they expect the chaser to continue chasing the target. If the two agents suddenly change roles and the target starts chasing, children are surprised (Rochat, Striano, & Morgan, 2004). Further, when 9-month-olds are shown displays of geometric shapes chasing one another, brain areas (P400 & N290) are activated that have previously been associated with processing social information (Galazka, Bakker, Gredebäck, & Nyström, 2016). Eleven-month-olds who repeatedly see a human hand reaching for one of two toys, form an expectation and anticipate that the hand will continue to reach for the same toy (Cannon & Woodward, 2012). Throughout the first year of life, children’s initial interest in animate stimuli (Mondloch et al., 1999; Rochat et al.,

1997) transitions into a more refined understanding of animacy and social interactions (Cannon & Woodward, 2012; Rochat et al., 2004). Children around the one year mark actively and purposefully engage with their environment (Tomasello, 1999) and have developed a sense of agency which allows them to make sense of others' actions (Falck-Ytter, Gredebäck, & von Hofsten, 2006).

As children grow older, their perceptions and beliefs about animate agents become more complex and they are able to communicate them verbally. Preschool-aged children believe that components of sentience (affect, autonomy and perception) are linked. Agents who have autonomy and can execute goal-directed actions should also be able to feel and express emotions. However, children do not believe that targets who exhibit inanimate traits are sentient (Weisman, Markman, & Dweck, 2015). When 5-9-year-olds are shown videos of geometric shapes remaining stationary or moving in animate or random motion patterns, they are most likely to ascribe living characteristics, such as ability to grow, breathe or get hungry to objects moving in an animate way (Poulin-Dubois & Heroux, 1994). Young children also use animacy to explain events that they do not know how to explain through natural forces. When children see two buttons dropped into a glass of water and one drops to the bottom while the other floats, preschool aged children are more likely to use explanations like the two buttons having varying intentions and goals, rather than using physical explanations, like the buttons' weight or material (Tunmer, 1985). According to Piaget (1929), children under the age of 10 are animistic and tend to overattribute animacy to inanimate entities. Both adults and children attribute animacy to inanimate shapes in motion, however, while adults are consciously aware that moving shapes on a screen are not actually alive (Heider & Simmel, 1944; Scholl & Gao, 2013), young children are still forming a comprehensive understanding of what is alive and what is not. At age 5, children are not always sure whether plants are alive. When children are asked to group targets under the category of "alive", they tend to exclude plants but include animals. However, if the category name is changed to "living things", they include both animals and plants (Leddon, Waxman, & Medin, 2008). Between the ages of 3-5 children also learn that death signifies the end of life and all activities an organism can engage in, while sleep does not, even though a lot of visual cues are shared between animals who have died or are sleeping (Barrett & Behne, 2005).

Current studies

Social perception, the ability to identify other agents and effortlessly interpret their intentions and actions is crucial to human interaction. In the empirical chapters following this introduction, I will outline my research investigating the ability to differentiate between social and non-social stimuli and specialized social processing. In some contexts, social stimuli, like bodies are perceptually objectified − processed by the visual system as objects rather than social stimuli. Conversely, even simple geometric shapes on a computer screen can be spontaneously seen as animate and goal-directed based on how they move.

I will discuss how allocation of attention and attentional shifts can drastically impact social perception.

Chapter two will begin by reporting in which context bodies, that should be processed as social stimuli, can be perceptually objectified and processed like objects (Bernard, Gervais, Allen, Campomizzi, & Klein, 2012; Reed et al., 2003). According to the Sexualized Body Inversion Hypothesis, female bodies are seen as sexual objects and reduced to their physical appearance. Therefore, they are visually processed as objects (Bernard et al., 2012). Our data suggest that the context within which we see a target matters and that perceptual objectification is not limited to female targets. Both male and female bodies can be perceptually objectified depending on how sexual a viewer perceives them to be.

Chapter three reports an investigation of how our visual system prioritizes social stimuli, using a change detection paradigm. Adults have been shown to notice changes to animate entities with faster reaction times and higher accuracy compared to inanimate changes (New, Cosmides, & Tooby, 2007). We used a habituation paradigm with 11-month-old infants to test whether they would also show a performance advantage for animate changes. Our results showed that infants, like adults, are more efficient at detecting changes relating to animate entities which is in line with the idea of our visual system being guided by animacy.

Chapter four explores 4-year-old children’s ability to detect a chasing agent among increasing numbers of distractors. Adult participants are capable of identifying a chasing agent even if they are surrounded by up to 10 distractors (Meyerhoff et al., 2014b). Starting in infancy, children are attuned to animate motion (Rochat et al., 1997). We set out to test whether pre-school aged children could detect a chasing agent when it was surrounded by distractors and whether they could physically identify the chaser by touching it on screen. Our results showed that at 4 years of age, children show a pop-out effect for chasing motion. Regardless of how many distractors were added to the display, children's reaction times did not change significantly. Search times did not increase with increasing number of distractors, suggesting that the chasing agent stood out amongst the distractor dots.

Chapter five integrates and summarizes the research described in Chapters two to four. I will discuss how our research fits within the broader context of the social perception literature and how it adds to the existing literature. Future directions and implications will also be discussed.

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Chapter 2: Sexualization leads to the visual processing of bodies as objects.

Hofrichter, R. & Rutherford, M.D. (submitted) Sexualization leads to the visual processing of bodies as objects. Submitted to Body & Society (June 03, 2019).

Preface

Female bodies are sexualized frequently which is particularly apparent in the way women are presented in the media (Archer, Iritani, Kimes, & Barrios, 1983). This sexualized presentation of women highlights their physical traits more than their mental abilities. Previous research suggested that when women's bodies are sexualized they are perceptually objectified – processed by the visual system as if they were objects (Bernard, Gervais, Allen, Campomizzi, & Klein, 2012; Fredrickson & Roberts, 1997). However, providing humanizing information about a sexualized female target mediate perceptual objectification (Bernard et al., 2015).

As faces and bodies are important socially, humans are experts as processing these social stimuli. This is evidence that our visual system has specialized processes dedicated to perceiving social object (Reed, Stone, Bozova, & Tanaka, 2003; Yin, 1969). Evidence of specialized social perception includes the inversion effect. Inverting images of faces and bodies impairs our ability to process them but inversion of objects images does not (Reed et al., 2003; Yin, 1969). The inversion effect is characterized by lower accuracy rates and slower reaction times for inverted face and body images. Performance for non-social objects remains unaffected by inversion. Because inversion affects processing of social stimuli compared to objects differently, the inversion effect can be used as a direct test of female bodies being perceptually objectified.

Bernard and colleagues' (2012) presented participants with upright and inverted images of male and female models wearing only swim or underwear. The results of their discrimination task showed an inversion effect for male body images but no inversion effect for female body images. The authors proposed the Sexualized Body Inversion Hypothesis (SBIH), arguing that the lack of an inversion effect for female bodies is due to them being processed as objects, while male bodies were processed as social stimuli. This pattern emerged for both male and female participants, indicating that it is not only men who objectify women, but women objectify female bodies as well.

In experiment one, we replicated Bernard and colleagues' findings and (2012) investigated whether the SBIH could be explained by lower level visual differences between the male and female image sets. To quantify discriminability of male versus female images, we ran an ideal observer analysis. After accounting for discriminability of images, we found a reliable effect in support of the SBIH.

In experiment two, we hypothesized that the objectification of female bodies could be overridden by creating a sexualized viewing context. We added audio clips to the procedure which outlined a target's sexual history. We hypothesized that providing additional information about the target might impact how they are visually processed. Audio clips were either high or low in sexualization. Results showed that perceptual objectification can be induced for male targets and is not exclusive for female bodies. Further, targets paired with high sexualization audio files were more likely to be perceptually objectified than targets paired with low sexualization audio files. Therefore, level of sexualization, not gender of the target, leads to perceptual objectification.

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Abstract

The visual system processes social stimuli differently than objects. Bernard et al.’s (2012) Sexualized Body Inversion Hypothesis (SBIH) suggests that female bodies are objectified, and therefore processed as objects as evidenced by a greater inversion effect for male than female bodies in a discrimination task. However, physical differences between Bernard’s image sets (male, female) could account for these differences. Using an ideal observer analysis, we quantified discriminability of the stimuli. Accounting for discriminability, there remained a reliable effect, supporting the SBIH. In experiment two, we tested how varying degrees of sexualization affect objectification of bodies. Target images were paired with audio files describing targets’ sexual history. Across target sex, less sexualized targets showed a larger inversion effect, like social stimuli, compared to more sexualized targets. Overall, we found support for the SBIH, and our results suggest that male and female bodies can be perceptually objectified depending on degree of sexualization.

Keywords: Body Perception, Ideal Observer, Sexual Objectification, Body v. Object Perception, Inversion Effect.

Introduction

The human visual system processes social stimuli, such as faces and bodies, differently than other objects. While faces (Maurer, Le Grand, & Mondloch, 2002) and bodies (Peelen & Downing, 2007) are processed configurally, non-social objects are processed featurally. The inversion effect refers to the fact that the processing of face (Yin, 1969) or body images (Reed et al., 2003) is impaired by inversion but object processing is not (Stein, Sterzer & Peelen, 2012). Inversion disrupts the configuration of features within an image. Therefore, only face and body processing which rely on configuration of features are impacted. The inversion effect is quantified as differences in accuracy or reaction time across inverted versus upright trial types and is taken as evidence of specialized visual processing.

Bernard et al. (2012) reported a difference in the inversion effects across male and female body images. They showed participants upright and inverted images of male and female models depicted wearing only swim- or underwear. Participants completed a matching task in which they were shown mirror images side by side and had to indicate which one matched the original image. While there was an inversion effect for images of male bodies, as would be expected for social stimuli, there was no significant inversion effect for images of female bodies. The lack of an inversion effect is usually characteristic of object processing. Bernard and colleagues proposed the Sexualized Body Inversion Hypothesis (SBIH), suggesting that while the human visual system processes male bodies as social stimuli, female bodies are visually processed as objects (2012).

The Objectification of Women

According to the objectification theory, women are not seen as human beings but are reduced to their bodies and viewed as sexual objects (Fredrickson & Roberts, 1997; Heflick & Goldenberg, 2014). For example, in popular media, there is a greater focus on women's physical traits than on their mental abilities (Archer, Iritani, Kimes, & Barrios, 1983). Several studies have offered evidence supporting the idea that sexualized female bodies are perceptually objectified and processed featurally. When presented with images of scrambled versus intact sexualized bodies, participants showed higher recognition rates for scrambled female body parts than whole female bodies (Bernard et al., 2015b). Further, processing of faces and bodies has been associated with a negative amplitude in event-related potential waves, called the N170. Because faces and bodies are processed configurally, processing them when they are presented in inverted orientation requires more cognitive resources, resulting in a larger N170. While inversion or scrambling of body images is associated with a large amplitude in N170 ERP waves, inversion or scrambling of sexualized body images does not modulate the N170 (Bernard et al., 2018a). An eye-tracking study also showed that participants who saw sexualized female targets spent less time looking at faces and more time looking at female targets' breasts (Cogoni et al., 2018). In sum, when we view sexualized bodies, attention is turned towards sexualized body parts during early stages of perception and sexualized targets are perceptually processed as objects rather than human beings.

This early attentional focus also affects our judgments of others (Bernard, Gervais & Klein, 2018b). For example, in one study, participants who focused on a woman's appearance were less likely to describe her with human-like traits, such as warmth and competence. In contrast, focusing on men's appearance did not lead to a similar shift, and this was true for both male and female viewers (Heflick et al., 2011). Therefore, sexualized targets are not only perceptually objectified but sexualization also affects how observers judge others.

Alternative explanations for the difference across model sets

There may be low-level differences between the male images and female images in Bernard et al.'s stimulus set that explain the difference in participants' performance without having to appeal to the SBIH (Tarr, 2013; Schmidt and Kistemaker, 2015). For example, the body postures of female models are more distinct than are those of male models: While most males are presented with their bodies facing the camera straight-on and their arms at their sides, females often have one arm akimbo or have their hips shifted to one side (see Figure 1).

Figure 1. Example of male target image versus female target image from Bernard et al. (2012)

Instead of inverting images from the upright condition and using them in the inverted condition, Bernard et al. used a different set of images for the inverted condition, so it is not clear whether any effect found is due to images in the inverted condition being upside down or due to physical differences in the upright and inverted images. To address the issues of using different image sets for the upright and inverted condition, Bernard et al. (2015a) ran a follow up study in which they replicated the 2012 study using all of the original stimuli both in upright and inverted orientation. They found both a significant main effect for target sex and orientation as well as a significant target sex by orientation interaction. While an inversion effect was found for female images, it was significantly smaller than that observed for male targets.

Schmidt and Kistemaker (2015) proposed that more asymmetrical images are easier to discriminate from their mirror image, and that differences in symmetry between the two stimuli sets (male and female) could account for the observed differences in performance. To test their hypothesis, they measured the symmetry of each image by drawing axes through body parts and measuring the angles between the axes. They found that symmetry did significantly differ across the stimuli set. Next, they created their own stimulus set with equal symmetry across stimuli and replicated Bernard et al.'s (2012) paradigm. Using the new stimuli, they did not find support for the SBIH. In response, Bernard, Gervais, Allen, and Klein (2015a) argued that the fact that Schmidt and Kistemaker (2015) did not replicate Bernard et al.'s findings using a different stimuli set does not directly oppose the SBIH. The lack of a significant effect could be due to lower levels of target sexualization in Schmidt and Kistemaker's stimuli set. Cogoni and colleagues (2018) found that asymmetry acted as a moderator in inversion effects, but level of sexualization did have an effect that could not be entirely accounted for by symmetry cues. Further, Bernard and colleagues (2019) recently investigated the effect of the model's suggestiveness by comparing neutral versus suggestive postures that were matched on symmetry. They found that perceptual objectification was driven by posture suggestiveness, regardless of symmetry cues.

While we agree that symmetry likely plays a role in mirror-image discrimination, Schmidt and Kistemaker's (2015) analysis provides no estimate of how large a difference in symmetry would have to be to influence participants' performance. Further, other factors that could potentially play a role in mirror-image discrimination such as shape from shading cues (Kemp, Pike, White & Musselman, 1996) or complexity of target images (Tarr, 2013) are not measured by Schmidt and Kistemaker. To offer a more comprehensive estimate of discriminability that encompasses symmetry, shape from shading and complexity cues, the current study uses an ideal observer analysis to quantify discriminability.

Ideal Observer Analysis

An ideal observer is a theoretical model often used in vision research to quantify how much information an image offers an observer to complete a given task (Geisler, 2011). Its implementation is computer-based. We chose an ideal observer analysis as it uses all information available in an image to solve a task as efficiently as possible (Barlow, 1978). As it considers all available information, the ideal observer theoretically performs any perceptual task at optimal level. Therefore, a simulation of this ideal performance provides us with a quantitative estimate of how difficult a task is. See Geisler (2011) for a detailed description of ideal observer analyses and their use in vision research. The ideal observer analysis is the most reliable tool available to measure differences between stimuli set as it is not limited to one factor, such as symmetry, but considers all available information. The ideal observer's performance would not be influenced by target sex as its performance is simulated by a computer. Therefore, it offers an objective measurement of discriminability.

The Current Study

The goals of the current study were to 1) replicate Bernard et al.'s (2012) study and to use an ideal observer analysis to test the SBIH once discriminability of images is accounted for and 2) test whether the level of sexualization of the depicted model can be manipulated through audio files and how sexualization impacts the inversion effect.

In experiment 1, we replicated Bernard et al.'s study using the original stimuli set. Next, we ran an ideal observer analysis comparing each image to its mirror-image to quantify the discriminability of each image. Then, we tested whether discriminability scores from our ideal observer analysis would predict participants' accuracy scores and whether there was a significant residual effect of sex of model on the inversion effect. If discriminability scores entirely account for participants' performance on the task perfectly then there would be no support for the SBIH. Any residual difference in performance across the two sets of images (male and female) that is not accounted for by discriminability can be taken as support for the SBIH.

In experiment 2, we created high and low sexualization trials by playing an audio file containing information about the target's sexual history on each trial before a participant saw the target image. We know that focusing on sexual body parts impacts visual processing and verbal judgements of others (Bernard et al., 2012; Heflick et al., 2011). Therefore, we are interested in whether the context within which participants see an image impacts how they process it. If so, we would expect to see a larger inversion effect for images in the low sexualization condition compared to a high sexualization condition.

Experiment 1: Replication of Bernard et al. and Ideal Observer Analysis

Method

We confirm that data collection complied with current APA Ethical Principles of Psychologists and Code of Conduct and that all measures, manipulations and exclusions in the study are disclosed.

Participants

Fifty-three undergraduate University students (26 male, 27 female, *M* = 19, *SD* = 2.5 years) participated in exchange for course credit for their Introductory Psychology course. All participants had normal or corrected-to-normal vision. Data from five participants had to be excluded due to computer failure (2) or participants not completing the task as instructed (3).

Stimuli

Stimuli were the 48 photographic images (24 male, 24 female) originally used by Bernard et al. (2012) and made available for this study by the author. Models were minimally clothed, wearing only underwear or swimsuits. The images were originally found on the internet and in advertisements. Half of the images were upright, and half were inverted (12 upright, 12 inverted for each sex). The images shown in the inverted condition are not inverted versions of the upright images but are a different set of images. Distractor images were left-right mirror-images of the original images.

Procedure

Ideal Observer Analysis: We used a computer simulation to estimate the performance of an ideal observer. Our ideal observer analysis requires images to be grayscale, so we rendered our color images in grayscale.

On each trial, the ideal observer algorithm was presented with a two-alternative forced-choice (2AFC) signal-detection task (Eagle 1998), in which it compared one of the original images with Gaussian noise added (target) to two test images: the original noise-free image and its mirror-image (see Figure 2).

Figure 2. Example of one trial of 2AFC task: Ideal observer compares noisy target picture to noise-free counterpart and mirror image.

The algorithm correlated luminance across pixels, comparing each pixel from the noisy target image to the pixels in the corresponding location in both test images. After comparing luminance across all pixels, it selected the test image that was a better match (higher average correlation) to the noisy image.

The dependent measure was the root mean square (RMS) contrast threshold, which quantifies the amount of noise that needs to be added to the target image for the ideal observer to only pick the correct test image 75% of the time. If no noise was added to the test image, the ideal observer would always pick the correct test image. The RMS contrast is called the root mean square contrast as it is obtained by calculating the standard deviation of luminance within a stimulus (Peli, 1990; Bex & Markous, 2002). QUEST, a Bayesian adaptive staircase method was used to approximate how much noise needed to be added to each test image to reach the 75% RMS contrast threshold (Watson & Pelli, 1983). This approximate level of noise was used as a starting point. The ideal observer was then repeatedly presented with the same target and test images. Every time the ideal observer successfully selected the correct test image, more Gaussian white noise was added to the noisy target image to lower the RMS contrast (Pelli & Bex, 2013; Watson & Pelli, 1983). More noise was gradually added to the target image until the ideal observer reached the threshold, only picking the correct test image 75% of the time. We use this threshold to quantify how much information is available in a stimulus. The lower the contrast of an image, the lower the signal to noise ratio. If the ideal observer is able to match a noisy image with a low RMS contrast (high level of noise and low level of signal) to the correct test image, we can conclude that the two test images are relatively easy to discriminate as the noisy image could be successfully matched regardless of the added noise. 100 independent simulations were run to obtain 100 contrasts for each of the 48 identities (12 upright males, 12 inverted males, 12 upright females, 12 inverted females).

Replication: After participants had given their informed consent, they sat in front of a 43 cm NEC Multisync LCD 1700V screen. The screen and a keyboard were connected to a Dell XPS 8700 Desktop Computer running the Windows XP operating system. Only the screen and the keyboard were visible to the participant. The procedure was run using the Open Sesame 2.9.5 Software. Participants sat approximately 50cm from the computer screen.

Trials followed the procedure described by Bernard et al. (2012). An image was presented on the screen for 250ms, followed by a blank screen (1000ms), then the same image was presented alongside a distractor until the participant responded. Participants had to indicate via keyboard which of the two images they had seen just before the blank screen. The order in which images were presented was randomized. Participants were asked to respond as quickly and accurately as possible. Reaction time (RT) and accuracy levels were recorded.

Before the experimental trials, participants completed four practice trials. Practice trials were identical to experimental trials except that the stimuli were not images of people but were different coloured circles (e.g. blue circle versus green circle). Bernard et al. (2012) did not mention practice trials in their study, but we wanted to ensure that participants understood the task, thereby limiting the number of participants that would need to be excluded due to not performing the task correctly.

Results

Ideal Observer Analysis: To test whether the male and female image sets differ with respect to discriminability, we ran a 2 (Target Sex: Male, Female) x 2 (Orientation: upright, inverted) factorial analysis of variance (ANOVA), using the ideal observer RMS thresholds as the dependent variable. Stimulus Sex and Stimulus Orientation were between-stimulus variables and the RMS contrast threshold for each target image was the dependent variable. As we wanted to test discriminability for all images used in the study, this analysis was conducted at the item level. It revealed no significant main effect of Target Sex (*F*(1,46) = 0.10, *p* = .75). Discriminability among female targets (*M*= 2.51e-4, *SD*= 3.55e-05) was equal to that among male targets (*M*= 2.55e-4, *SD*=3.88e-05). No significant main effect of Orientation (*F*(1,46) = 0.12, *p* = .73) emerged with upright (*M*=2.51e-4, *SD*= 3.59e-05) and inverted images (*M* =2.54e-4, *SD*= 3.84e-05) being equally easily discriminated. Finally, there was no significant Sex by Orientation Interaction (*F*(1,46) = 0.43, *p* = .51). Average thresholds ranged from 1.79e-4 to 3.29e-4.

Replication: Our study was designed to test whether the physical discriminability of the images predicted human performance. RMS contrast threshold and Accuracy scores are negatively correlated (correlation coefficient = -0.39, *p* < .01) with Accuracy scores increasing as the RMS contrast threshold decreases. There was no difference in performance across sex of participant (*F* (1,44) = 0.07, *p* = .79) so data were collapsed across participant sex. We ran a hierarchical regression analysis using Accuracy as the criterion variable, controlling for RMS contrast threshold and with Target Sex and Orientation as within-subject variables. It revealed that discriminability did predict human performance ($F(1,44) = -2.82$, $p < .001$, adj. $R^2 = .13$). After RMS contrast threshold was controlled for, the main effect of Orientation was still significant ($F(1,44) = 4.94$, $p < .04$, adj. $R^2 = .23$). Participants were better able to recognize upright images (M= 79.77, SD= 14.67, 95% CI [78.46 – 84.48]) compared to inverted images (M= 70.14, SD= 16.36, 95 % CI [68.27 – 74.99]). The main effect of Target Sex also remained significant ($F(1,44) = 24.02$, $p < .001$, adj. $R^2 = .04$). Participants were better able to recognize images showing females (M= 79.26, SD= 16.06, 95% CI [75.96 – 82.55]) than images showing males (M=73.85, SD=16.10, 95% CI [70.54 – 77.15]). Critically, the Target Sex by Orientation Interaction ($F(1,44) = 4.99$, $p < .031$) as predicted by the SBIH also remained significant. While participants recognized upright (M= 81.38, SD= 15.56, 95% CI [76.82 – 85.95]) and inverted (M= 77.13, SD= 16.44, 95% CI [72.31 – 81.95]) images of females equally well ($t(46) = 1.82$, p =.07, d =.27), they performed better for upright images of males (M= 81.56, SD= 13.89, 95% CI [77.49 – 85.63]) than for inverted images of males (M= 66.13, SD= 14.48, 95% CI [61.89 – 70.36], t (46) = 5.56, $p < .001$, d = 1.09) . There was a stronger inversion effect for the male images than for female images. In addition, participants performed better on trials showing inverted images of females (M= 77.13, SD= 16.44, 95% CI [72.31 – 81.95]) than inverted images of males (M= 66.13, SD= 14.48, 95% CI

[61.89 – 70.36], *t* (46) = 3.8, *p* < .001, *d* = .71). (See Figure 3)

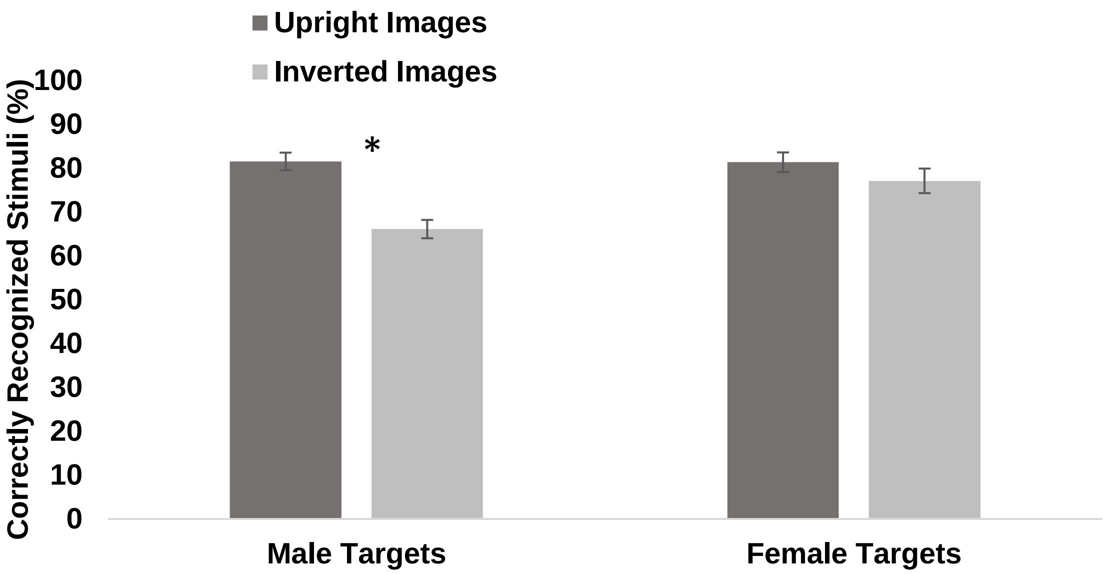

Figure 3. Level of Accuracy as a function of Target Sex and Orientation in experiment one. Error bars indicate ± SEM

Discussion

We replicated Bernard et al.'s (2012) pattern of results, by finding a larger inversion effect for male compared to female images. While accuracy did not differ significantly across upright and inverted female images, performance significantly decreased for male images when they were inverted. This was true for both male and female observers.

Further, we conducted an ideal observer analysis to quantify discriminability of images and to test whether the above described effects are due to lower level visual differences between the male and female image sets. While discriminability scores did predict participants' performance, results still revealed significant residual effects once discriminability was controlled for. There was still an inversion effect for male but not female targets. These findings support the SBIH and suggest that Bernard and colleagues' findings were not based on an artifact of the stimulus set.

Experiment 2: High versus low sexualization

Both the SBIH (Bernard et al., 2012) and Objectification Theory (Fredrickson & Roberts, 1997) suggest that women's bodies are viewed as objects when they are sexualized. If this is correct, then two questions follow: 1) Could male bodies be objectified too if they were sexualized? and 2) does the extent to which women's (and men's) bodies are objectified vary, according to how sexualized they are?

Bernard, Gervais, Allen, Delmée and Klein (2015b) found that providing humanizing information about sexualized female targets, such as giving information about their job and their positive characteristics, led to less perceptual objectification and created an inversion effect for female targets. Further, reducing or increasing the salience of female sexual body parts, including breasts, hips and groins, also impacted the degree to which female targets were perceptually objectified (Bernard et al., 2015b). This research suggests that the degree to which a target is sexualized does modulate perceptual objectification.

Further evidence for the idea that perceptual objectification can be modulated comes from Civile and Obhi (2015) who suggested that how powerful participants feel impacts how much they perceptually objectify other people. They primed participants to either feel high or low levels of power and then had them complete a recognition task with upright and inverted images of sexualized targets. They found while high-power male participants perceptually objectified female targets but not male targets, high-power female participants only objectified male targets. Both male and female low-power participants showed an inversion effect for male and female targets. Based on these results, perceptual objectification is not limited to female targets, but male targets can be objectified too, depending on context.

Experiment 2 was designed to test how varying degrees of target sexualization would impact perceptual objectification of both female and male targets. We encouraged participants to view models more or less sexually, by randomly pairing images from Bernard et al.'s (2012) original stimuli set with audio files that described a more or less sexually promiscuous history of the target.

Method

Participants

Sixty-nine undergraduate University students (32 male, 37 female, *M* = 18 , *SD* = 1.9 years) participated in exchange for course credit for their Introductory Psychology course. All participants had normal or corrected-to-normal vision. Data from nine participants had to be excluded due to computer failure (3) participants not completing the task as instructed (4), or experimenter error (2). Sample size was determined by calculating how many participants were needed to be 95% confident that the sample mean would be within the desired margin of error of the true population mean, using standard deviation of accuracy scores reported by Bernard and colleagues.

Stimuli

Experiment 2 used the same images as experiment 1. In addition, we recorded audio clips designed to induce high and low levels of sexualization on the part of the depicted models.

Stimulus Development

Undergraduate students rated 72 scenarios on a 5-point Likert scale, reaching from “Not sexual at all” to “Highly sexual”. The 24 highest and lowest rated scenarios were recorded. There were no significant differences in ratings for male compared to female scenarios ($t(23)= -.05$, $p = .96$). Each scenario was recorded as a male and female version (see below for example scenarios). Whether participants heard the male or female version varied across participants. All audio files were recorded by the same female undergraduate research assistant who was a native English speaker.

Example of low sexuality scenario: “Becky/Martin just finished University. She/He is in a committed relationship with her/his high school sweetheart.”

Example of high sexuality scenario: “Anna/Daniel is in her/his first year of University. She/He often spends her/his weekends at the bar looking for men/women.”

Procedure

Experiment 2 followed the same procedure as experiment 1, but at the beginning of each trial, participants listened to an audio file while looking at the fixation cross on the screen. Whether a specific target image was matched with a high or low sexualization audio file alternated from one participant to the next. Images were paired randomly with one of the possible 12 high or low sexuality audio files.

Results

We ran a hierarchical regression analysis using Accuracy as the criterion variable and RMS contrast threshold, orientation, target sex and sexualization as predictors. There was no difference in performance across sex of participant (*F*(1, 57) = .309 , *p* = .59) so data were collapsed across participant sex.

As in experiment one, the results showed that discriminability predicted human performance (*F*(1, 57) = 6.99, *p* < .01, adj. R^2 = .01). Further, controlling for RMS contrast threshold, there was still a significant main effect of Orientation (*F*(1, 57) = 73.41 , *p* < .001, adj. R^2 = .15). Participants performed better for upright images (*M*=90.97, *SD*= 12.08, 95% CI [87.9-94]) than inverted images (*M*=76.14, *SD*= 21.97, 95% CI [70.6-81.7]). There was a significant main effect of Target Sex (*F*(1, 57) = 10.16, *p* < .001, adj. R^2 = .01). Participants were more accurate with female targets (*M*=85.47, *SD*=19.27, 95% CI [80.6-90.3]) than male targets (*M*= 81.6 *SD*=18.9, 95% CI [76.8-86.4], see Figure 4).

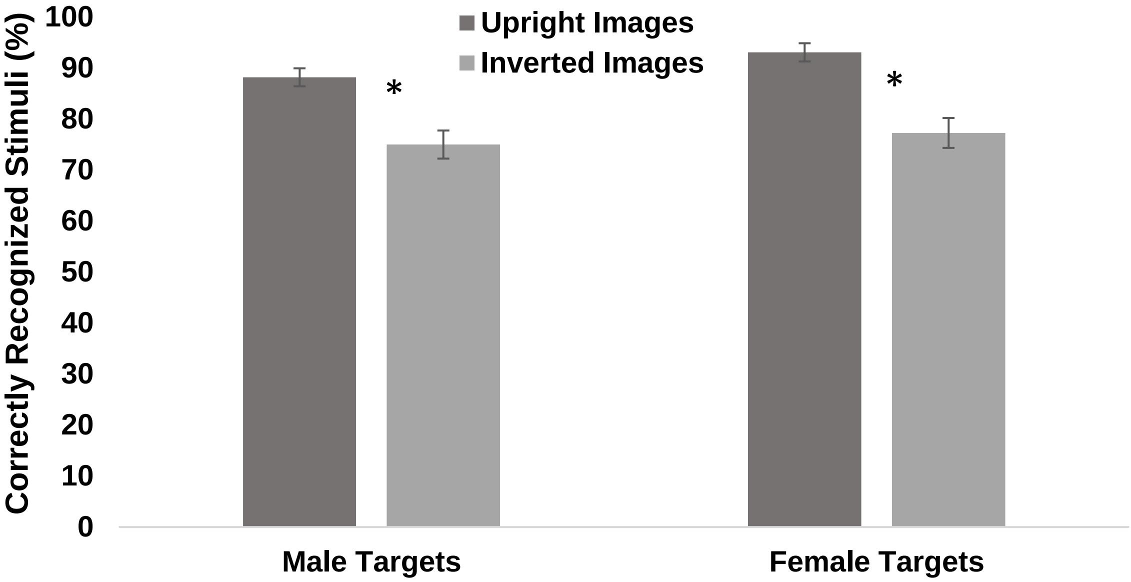

Figure 4. Level of Accuracy as a function of Target Sex and Orientation in experiment two. Error bars indicate ± SEM

There was also a significant main effect of Sexualization ($F(1, 57) = 20.6$, $p < .001$, adj. $R^2 = .03$). Participants were more accurate with targets matched with high Sexualization audio files (M=87.08, SD=14.93, 95% CI [84.4-89.8] compared to targets matched with low Sexualization audio files (M=80.01, SD=22.16, 95% CI [76.1-84].

There was no significant Target Sex by Orientation Interaction ($F(1, 57) = 1.61$, $p = .21$). To directly compare results between experiment one and two, we analyzed differences in performance for each Target Sex by Orientation. Like in experiment one, there was an inversion effect for male body images in experiment two ($t(29) = -4.38$, $p < .001$, $d = .58$): participants performed better for upright

(*M*= 88.19, *SD*= 13.63, 95% CI [85-91.9]) compared to inverted images (*M*= 75, *SD*= 21.34, 95% CI [72.9-83.7]) However, while there was no inversion effect for female targets in experiment one, there was also a significant inversion effect for female body images in experiment two ($t(29)= -5.26$, $p < .001$, $d = .71$): participants performed better for upright (*M*= 93.75, *SD*= 13.86, 95% CI [90.2-97.3]) compared to inverted images (*M*= 77.27, *SD*= 22.69 , 95% CI [71.2-82.6]) (see Figure 4)).

There was a significant Orientation by Sexualization interaction ($F(1, 57) = 10.93$, $p < .001$, adj. $R^2 = .19$). Participants performed significantly better for inverted images paired with high sexualization audio files (*M*= 85.83, *SD*= 14.91, 95% CI [82.1-89.6]) compared to inverted images paired with low sexualization audio files (*M*= 69.95, *SD*= 24.78, $t(29)= 6.18$, $p < .001$, $d = .81$, 95% CI [63.7-76.2]) but equally well for upright images paired with high sexualization audio files (*M*= 89.44, *SD*= 14.95 , 95% CI [85.7-93.2]) and low sexualization files (*M*= 88.75 , *SD*= 12.44, $t(29)= .39$, $p = .71$, $d =.05$, 95% CI [85.6-91.9]). In other words, there was a larger inversion effect for images paired with low sexualization audio files than with high sexualization audio files (see Figure 5).

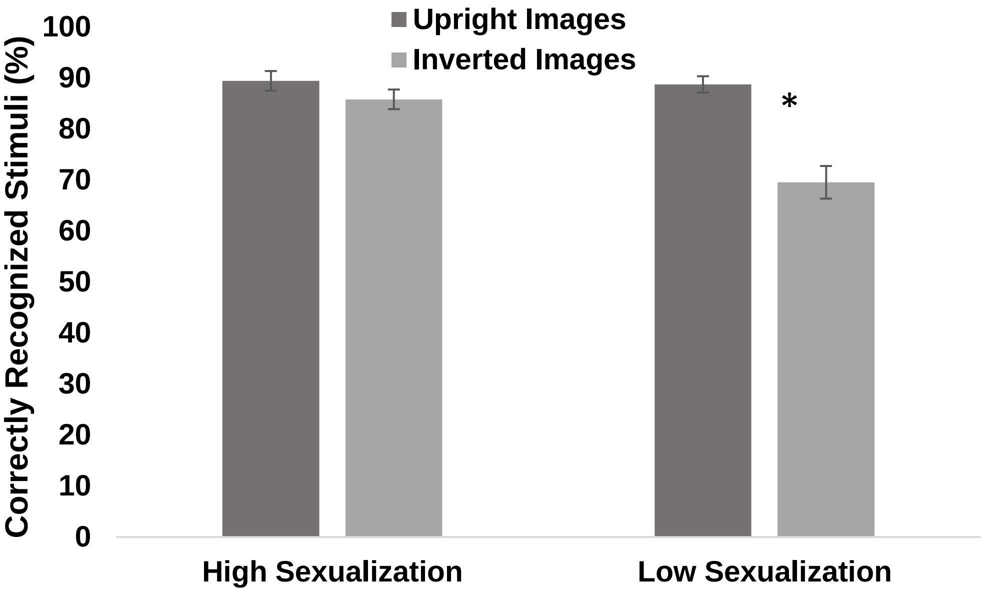

Figure 5. Level of Accuracy as a function of Sexualization and Orientation in experiment two. Error bars indicate ± SEM

For images paired with high sexualization audio files, participants performed marginally better for upright (*M*= 89.44, *SD*=14.96, 95% CI [85.6-93.2]) compared to inverted images (*M*= 85.83, *SD*= 14.91, *t*(29)= -1.87, *p* = .07, *d* =.24, 95% CI [82.1-89.6]). For images paired with low sexualization audio files, participants performed better for upright (*M*= 88.75 *SD*= 12.44, 95% CI [85.6-91.9]) compared to inverted images (*M*= 69.56, *SD*= 24.78, *t*(29)= -7.6, *p* < .001, *d* =1.03, 95% CI [63.3-75.8]).

There were no other significant effects or interactions. There was no significant Sexualization by Target Sex interaction (*F*(1, 57) = .25, *p* = .62).

There was also no significant three-way interaction between Sexualization, Target Sex and Orientation (*F*(1, 57) = 2.46, *p* = .12).

Discussion

Results showed a significant Sexualization effect. Overall, participants performed better for target images paired with high Sexualization audio files compared to images paired with low Sexualization audio files. In addition, while participants performed equally well for upright and inverted female images in experiment one, results of experiment two showed a significant inversion effect for female body images. As the only difference between experiment one and two was the addition of audio files, this result suggests that our manipulation did have an effect. Further, there was a significant Sexualization by Orientation interaction, revealing a larger inversion effect for images paired with low sexualization audio files compared to those paired with high sexualization audio files. This suggests that the extent to which bodies are processed as social stimuli rather than objects can be manipulated if the participant is cued to sexualize the depicted individual. This effect was apparent across target sex. Since we found an inversion effect for female targets in experiment two but not experiment one, one possible explanation is that this effect was driven by performance for target images paired with low sexualization audio files. In experiment one, female targets were objectified when images were presented without audio files. It seems that the default for sexualized female targets was to be perceptually objectified and therefore pairing female target images with high sexualization audio files should have little effect. However, pairing female targets with low sexualization audio files, providing more humanizing information, could have induced the observed inversion effect in experiment two.

As in experiment one, participants in experiment two performed better for upright compared to inverted images. Further, accuracy rates were higher for female compared to male images. However, once discriminability of images was accounted for, results for experiment two showed no significant Orientation by Target Sex interaction. This could be due to the fact that there was an inversion effect for both male and female targets in experiment two, while only male images showed an inversion effect in experiment one.

Our results suggest that sexual objectification is not limited to female targets but rather it can be both induced or reduced by manipulating the sexualizing information with which the images are presented.

General Discussion

Using the stimulus set provided by Bernard et al. (2012) we replicated their pattern of results. Although the inversion of images significantly impaired recognition, the strong inversion effect was driven by performance on trials involving images of males. Participants performed equally well for upright and inverted images of female bodies. With images inverted, participants performed better when viewing female compared to male bodies. These patterns emerged regardless of observers' sex. These results are consistent with the SBIH.

Using our ideal observer analysis, we were able to control for multiple low-level confounds including symmetry cues, shape from shading cues and complexity of target images. Discriminability scores generated by the ideal observer analysis did predict performance. This is in line with Tarr (2013) and Schmidt and Kistemaker (2015) who had suggested that the effects as reported by Bernard and colleagues (2012) were confounded. However, after accounting for discriminability, there was still a reliable difference in the magnitude of the inversion effect across the male and female image set, supporting Bernard and colleague's (2012) original prediction. This difference is consistent with the idea that both male and female participants visually process images of minimally-clothed women as objects but visually process images of minimally-clothed men as social stimuli.

Objectification theory suggests that women are viewed as objects, and that this objectification is related to the sexual portrayal of female bodies (Fredrickson & Roberts, 1997). Using an inversion paradigm, we found evidence that both male and female bodies can be objectified if they are portrayed as sexual. We used the strength of the inversion effect after pairing target images with high and low sexualization audio files to test whether sexualization would impact perceptual objectification.

Results showed a larger inversion effect for images in the low sexualization condition compared to the high sexualization condition, across sex of model. Further, we found an inversion effect for both male and female images.

Both findings show that the objectification that follows sexualization is not exclusive to female models but can be manipulated based on how sexualized female and male bodies are perceived to be. The fact that we found an inversion effect, a hallmark of social perception, for female targets in experiment two is likely due to low sexualization audio files focusing on qualities such as loyalty and commitment, humanizing targets rather than presenting them as sexual objects. This is in line with previous research, such as Bernard and colleagues' findings (2015b) that showed that perceptual objectification could be reduced for female targets by providing humanizing information. Our results also add to Archer and colleagues' findings (1983) suggesting that focusing on women's bodies rather than their mental abilities leads to their objectification. This is a crucially important finding as previous research suggested that there are negative effects to women who are being objectified. They are dehumanized (Heflick et al., 2011) and sexual objectification has also been linked to victim blaming and decreased perceived suffering of victims (Loughnan, Pina, Vasquez & Puvia, 2013). Further, not only do men objectify women, but women objectify themselves and other women (Fredrickson & Roberts, 1997; Bell, Cassarly & Dunbar, 2018). Calogero (2013) found that women who self-objectify are less likely to engage in social activism, such as talking about gender equality or signing petitions to support said cause. The fact that women experience the negative effects of objectification, does not make them more likely to advocate for themselves and other women. Because women hesitate to discuss objectification and gender equality, they might be unaware of how prevalent these issues are. Therefore, it may be fruitful to research and discuss objectification, to raise awareness, empower women and develop strategies of how objectification can be combatted in the media, the work place and even in day-to-day conversations.

Future Directions

Since we know that discriminability does affect participants' performance in this task, we suggest that rather than using a paradigm based on mirror-image discrimination (Bernard et al., 2012; Schmidt & Kistemaker, 2012), a paradigm more like that employed by Reed et al. (2006) might be better to investigate sexual objectification. In their study, participants were shown a picture of an animated body (250ms), followed by a blank screen (1000ms). Then participants were shown either the same picture or a picture of the same body in a slightly changed posture. Participants had to indicate whether the second picture was the same as they had seen before or different. Having participants make same-different judgments instead of discriminating between mirror-images avoids the issue of discriminability between mirror-images. Similarly, Civile and Obhi (2015; see also Civile, Rajagobal & Obhi, 2016) used an old/new recognition task in their study investigating body inversion effects. Again, this type of task bypasses the issue of mirror-image discriminability.

Conclusions

Experiment one was designed to examine whether physical differences in the stimulus set could account for the performance difference reported by Bernard et al. (2012) or whether the reported difference in the inversion effect across male and female images sets was really evidence supporting the SIBH. We found evidence that the physical discriminability of the image did predict performance, but that there was still a reliable residual difference in performance across the stimulus sets, supporting the Sexualized Body Inversion Hypothesis. Results of experiment two showed that the objectification of bodies is not limited to female targets but can be induced or reduced for male or female models by manipulating cues to sexualization.

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Chapter 3: Early attention to animacy: Change-detection in 11-month-olds

Hofrichter, R., Siddiqui, H., Morrisey, M. & Rutherford, M.D. (submitted) Early preference for animacy: Change detection in 11-month-olds. Submitted to Journal of Cognition and Development (May 14, 2019).

Preface

If you are walking down the street, your attention will be drawn towards people and other animals, but you are likely to ignore a stationary park bench. Humans are efficient at picking out other animate agents in their environment and attend to them preferentially (New, Cosmides & Tooby, 2007, Altman, Khislavsky, Coverdale, & Gilger, 2016). When adult participants are tested with a change detection paradigm, they are more efficient at detecting changes to animate objects than changes to inanimate objects (New et al., 2007). Change blindness, the failure to detect a change, results from a lack of attention. Because we prioritize attention towards animate stimuli, we are more likely to experience change blindness when the changing object is inanimate. When an animate object is close to an inanimate change, detection latencies become even slower as the animate object is distracting (Altman et al., 2016).

New, Cosmides & Tooby (2007) proposed the animacy monitoring hypothesis and argued that prioritizing attention toward animate stimuli is adaptive. In the environment in which our species evolved, we constantly had to monitor movements of humans and other animals in case they presented a potential threat. Even young children know which stimuli are threatening and process them more efficiently than non-threatening stimuli (LoBue, 2010).

Since infants show a sensitivity towards animate stimuli (Mondloch et al., 1999; Rochat et al., 1997), we were interested to see if 11-month-old infants, like adults, would be more efficient at detecting changes to animate compare to inanimate entities (New et al., 2007). This would require them to attend to animate objects when they are presented and store a representation of them to later recognize that they have been removed. To test change detection in infants we used a habituation paradigm. Participant were presented with images of naturalistic complex scenes on a computer screen. While they viewed the images, their eye movements were recorded. Infants were shown the same image (Scene A) on a loop until they habituated. Once the infant habituated, they were presented with a second image (Scene A’) that was identical to the first image, except that an animate or inanimate object had been removed. If children dishabituated, it indicated that they noticed something was missing from the second image. Our results showed that, like adults, infants were more likely to notice changes to animate compared to inanimate objects.

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Abstract

Adults are faster and more accurate at detecting changes to animate compared to inanimate stimuli in a change-detection paradigm (New et al., 2007). We tested whether 11-month-old children are also faster at detecting animate than inanimate changes. During each trial, infants were habituated to an image of a natural scene (Scene A). Once the infant habituated to a scene, it was replaced by another scene that was identical except that an object was removed. Dishabituation suggested that infants had noticed the change. Infants dishabituated more often to animate compared to inanimate changes.

Keywords: animacy, change-detection, change-blindness, social attention

Introduction

Humans are efficient at detecting other animate agents in their surroundings and attend to them preferentially (New et al., 2007; Ro, Friggel, & Lavie, 2007). The ability to quickly distinguish between what is animate and what is inanimate is called animacy detection. Animacy detection was functional and allowed for fast identification of social partners and potential predators in the environment of evolutionary adaptedness (New et al., 2007). Failure to detect a potential predator could have resulted in injury or death, providing a selection pressure for the detection of animate stimuli (Öhman, Flykt, & Esteves, 2001). Selection pressures have facilitated the evolution of visual attention to animate stimuli, and this attention is recruited spontaneously, regardless of the context and current goals of the observer (New et al. 2007). Thus, animacy detection appears to be irresistible (Scholl & Gao, 2013).

Early Animacy Detection

Animacy detection is apparent early in life. Newborn infants show a preference for face-like stimuli compared to inanimate objects (Fantz, 1963). Even when stimulus familiarity is controlled for, infants show more interest in a person compared to an inanimate object (Legerstee, Pomerleau, Malcuit, & Feider, 1987). As early as 3 months of age, infants can distinguish between animate and inanimate motion (Rochat, Morgan, & Carpenter, 1997) and show a preference for animate motion (Frankenhuis, House, Barrett, & Johnson, 2013). The animate versus inanimate distinction plays a role in the development of infants' understanding of causality: Children are surprised if objects move on their own but not when people do (Woodward, Phillips, & Spelke, 1993). By the age of 8-10 months infants understand the social contingencies underlying animate motion and distinguish between different agents based on motion patterns (Rochat, Striano, & Morgan, 2004). Further, infants have expectations for how animate agents should act (Csibra, Gergely, Bíró, Koos, & Brockbank, 1999; Spelke, Phillips, & Woodward, 1995; Wagner & Carey, 2005) including an expectation of reciprocal social behaviour (Legerstee et al., 1987).

Attention to animacy in a change-blindness paradigm

New and colleagues (2007) used a change-detection paradigm to test whether changes to animate stimuli would be detected faster and more frequently than changes to inanimate stimuli, while controlling for expertise. Adult participants were presented with an image of a complex naturalistic scene (Scene A) for 250ms which was then masked by a blank screen. Then a second image was presented (Scene A'). Scene A' was either identical to Scene A, or one object had been removed from the scene. The object that was removed was either animate or inanimate. Scene A and A' alternated on a loop until participants could identify the change. Results supported the authors' prediction that reaction times for detection of animate changes would be faster and elicit higher hit rates than detection of inanimate changes. Participants were more likely to experience change-blindness, failing to detect changes, when the changed object was inanimate. This superior detection of changes in animate stimuli was independent of expertise. New and colleagues (2007) used vehicles as one of the stimulus categories, reasoning that if expertise was driving the effect, they should see an advantage for detecting changes to vehicles. Results showed no such advantage, despite the fact that in our current environment, vehicles pose a potential threat. Participants were not simply attending to entities that move or could be potentially dangerous.

The Current Study

The current study was designed to test for animacy detection in 11-month-olds using a change-detection paradigm akin to that used by New and colleagues (2007). Young infants have been shown to be sensitive to animate motion (Rochat et al., 1997; Frankenhuis et al., 2013) but few studies have tested infants' ability to detect changing elements in static images (Wang & Baillargeon, 2006). We were interested in testing whether children's sensitivity to animacy would translate to a change detection paradigm. To adapt the paradigm for use with infants, we used a habituation paradigm instead of the change-blindness paradigm. We chose 11-month-olds as our participants because infants this age should be able to detect animacy (Rochat et al., 1997) and be able to sustain attention for longer than younger infants. The stimuli in our study were a subset of the scenes used by New, Cosmides and Tooby (2007). Participants were habituated to Scene A. Once habituated, the child was presented with Scene A'. In addition, in our study, there was always a change between Scene A and A'. Using an eye tracker and live coding, we measured whether the child dishabituated to the change, suggesting that the child had noticed a difference between Scene A and A'. We predicted that children, like adults, would be more efficient at detecting changes to animate compared to inanimate entities.

Methods

Data collection complied with current APA Ethical Principles of Psychologists and Code of Conduct and all measures, manipulations and exclusions in the study are disclosed.

Participants

Thirty-six 11-month-old infants (20 female; *M*= 11.13 months, *SD*= .36) were recruited through an existing database for child participants. Parents reported their children's ethnicity as Hispanic (2), Asian (4) or Caucasian (30). Parents and their children were compensated for their time with $10. Data of ten participants were excluded from analyses due to computer/calibration failure (3), children not completing trials (3), or parents pointing out objects in the scenes (4).

Stimuli

The stimuli were colour images of complex, natural scenes (see Figure 1 for examples). We selected eight pairs (Scene A & A') from New, Cosmides and Tooby's (2007) original stimuli set: four pairs associated with changes to animate entities, and four scenes associated with changes to inanimate entities. Animate entities that were removed were a horse, a lion, a man, and an officer. Inanimate entities were a TV, a tree, a cup, and a building. Areas of interest (AOI) were created around the target (see Figure 1).

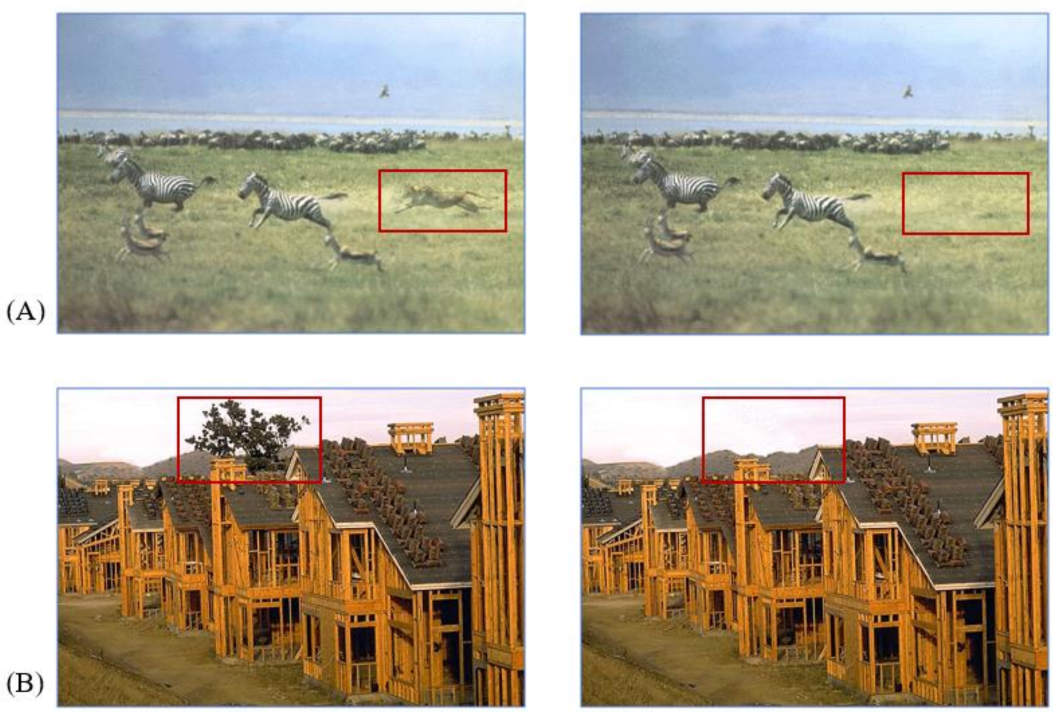

Figure 1. Examples of Stimuli with areas of interest highlighted.

We chose images in which the changing element was large so that infants would be more likely to notice the change. The average size of AOIs for animate and inanimate entities was equal (average area of AOI = 0.74 inches). Further, for the inanimate change images, we selected scenes that did not also include any non-changing animate objects because they could potentially distract participants from noticing the inanimate change (Altman, Khislavsky, Coverdale, & Gilger, 2016).

Habituation and Dishabituation

We defined Habituation as three trials with averaged looking time less than 50% of the average looking time of the first 3 trials. We also required children to look at the screen for at least three cycles of Scene A before attention dropped to meet habituation criteria. A researcher who stood beside the infant throughout the experiment observed and live-coded behaviour and noted how many cycles of Scene A the infant attended to. In addition to live coding, the eye tracker captured whether the child looked at AOIs. We only included trials in our analysis if infants had looked at the area of interest in Scene A at least once, to ensure that infants had an opportunity to notice the target in Scene A before it was removed in Scene A'.

Dishabituation was noted if 1) looking time recovered to above 50% of baseline looking time and, 2) the child looked at the area of interest in Scene A', the location of the removed object, at least once. Again, the researcher live coding would watch the child's behaviour and note whether the child reoriented towards the screen when Scene A' was presented.

Procedure

At the beginning of the session, parents completed a demographic survey providing information on the age, sex, and ethnicity of their infant. To track infants' eye movements, we use a Tobii T60XL eye tracker (24-inch screen; 1920 x 1080 pixels widescreen monitor). The infant was positioned in front of the eye tracker on the parent's lap approximately 24 inches away from the screen. Parents wore sunglasses to ensure that his or her eyes were not detected by the eye tracker.

At the beginning of each trial, an attention-grabber appeared: a video clip of a duck shaped rattle that shakes and makes a loud, quacking sound. The attention-grabber used was one included with the Tobii studio software and was shown continuously until it successfully directed the child's attention towards the screen. As soon as the child was looking directly at the screen, Scene A was displayed.

Scene A was displayed for 15 seconds. After 15 seconds, a blank screen masked the screen for 250 ms, then Scene A returned. This cycle continued until the infant had habituated to Scene A. Scene A was shown a minimum of 6 times and a maximum of 12 times. If a child did not habituate within 12 cycles, the trial was excluded from analysis. Once habituation was achieved, Scene A was masked again with a blank screen. Lastly, Scene A' was presented for 15 seconds, then the trial was over (see Figure 2). Scene A' was identical to Scene A except that one animate or inanimate entity was removed from the scene (for example in *Figure 1a,* the lion disappears in Scene A'. In *Figure 1b,* the tree disappears).

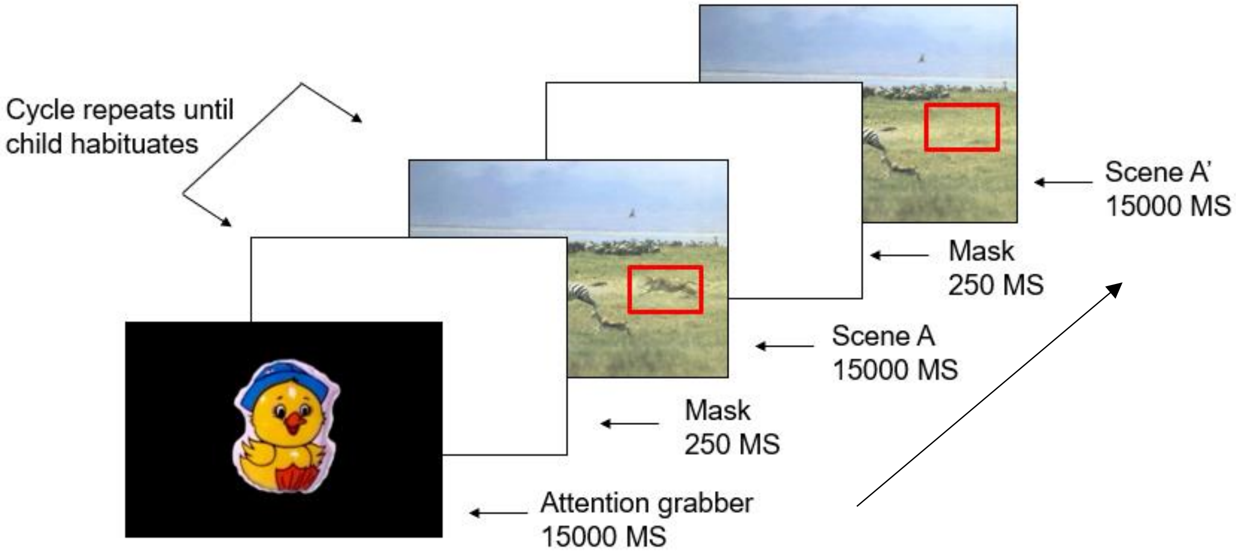

Figure 2. Trial Structure

Results

Dishabituation and Interest scores were calculated as a proportion relative to the number of trials a child completed and were calculated for animate and inanimate stimuli separately. For example, a child who watched 3 out of 4 possible animate change trials and dishabituated once would receive a Dishabituation score of 1/3 = 0.33 for animate trials. If the same child spent a total of 750 ms looking at animate AOIs, their Interest score for animate trials would be 250 (750/3 = 250).

We ran a paired-samples *t*-test with Animacy (animate versus inanimate) as our within-subjects independent variable and Dishabituation as our dependent variable. Our results showed that infants dishabituated significantly more often to changes in a scene if those changes were related to an animate (*M*= .24, *SD*= .037) *us inanimate (*M*= .11 ms, *SD*= .036) entity, *t*(25)= 2.3, *p*<.016 (see Figure 3).

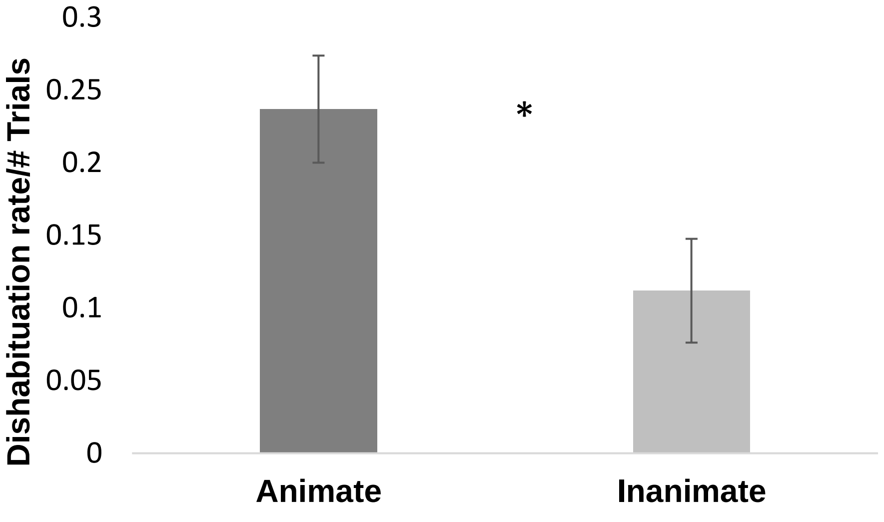

Figure 3. Dishabituation rates for animate versus inanimate changes. Error bars represent SD.

Next, we ran a paired-samples *t*-test with Animacy (animate or inanimate) as our within-subjects independent variable and Interest as our dependent variable. Interest was defined as infants' total fixation duration to animate versus inanimate areas of interest in Scene A as a proportion of completed animate versus inanimate trials. There was no significant difference between infants' looking time towards animate (*M*= 267 ms, *SD*= 134 ms) versus inanimate (*M*= 131 ms, *SD*= 61 ms) areas of interest (AOI), *t*(25)= .89, *p* =.38 (see Figure 4).

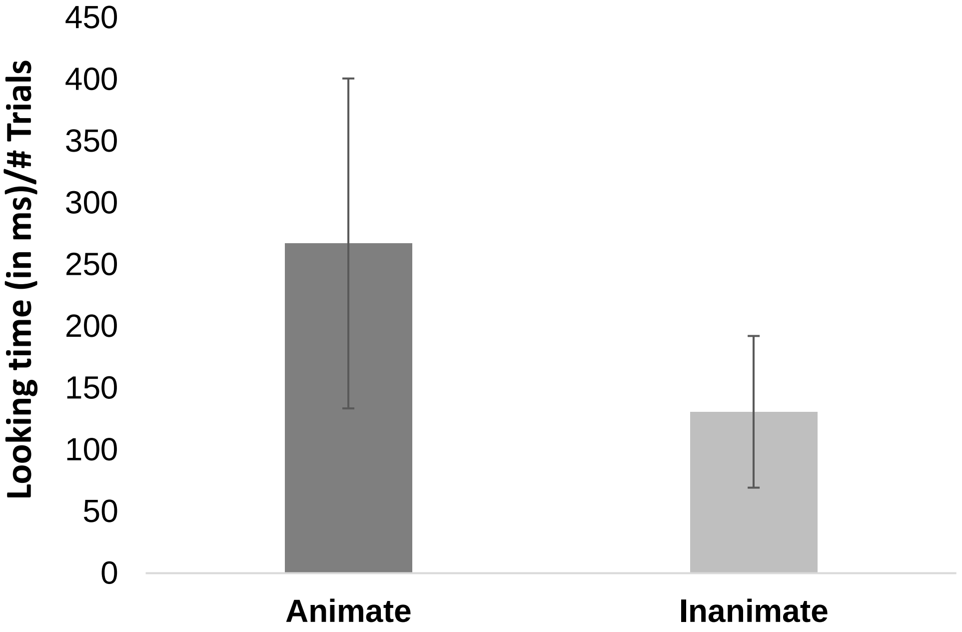

Figure 4. Interest towards animate versus inanimate areas of interest (AOI). Error bars represent SD.

Discussion

Our results revealed higher dishabituation rates for animate changes compared to inanimate changes. Infants were more likely to notice changes if an animate object was removed from the scene compared to an inanimate object, which is consistent with the findings reported by New and colleagues (2007). These results suggest that infants already have an attentional preference for animate objects as adults do. New and colleagues (2007) argued that performance advantages for animate entities were due to their functional significance in our evolutionary past. Animate objects in our study included a horse and a lion. These are animals that an infant might have never encountered before. Inanimate objects included objects like a TV or a cup. Most infants are more likely to have seen and interacted with objects like a TV or a cup than a horse or a lion, so familiarity cannot account for our results.

Our Interest measure did not show significant differences between attention to animate or inanimate objects during habituation. Infants did not show a significant looking time preference for animate versus inanimate AOIs. Based on previous research, we did not have an *a priori* expectation of Interest differing between animate and inanimate entities. Newborn infants have been shown to spend more time looking at static images of schematic faces versus random patterns (Fantz, 1963). However, previous research on infants' looking time towards animate versus inanimate moving objects has shown conflicting findings. While Frankenhuis and colleagues (2013) found that 4- and 10-month-old infants strongly preferred looking at animate motion, Rochat and colleagues (1997) only found this pattern for 3-month-old infants and reported a switch in preferential attention towards animate motion around 5 to 6 months of age. Rochat and colleagues argued that by 6 months of age, infants readily understood the social contingencies underlying the animate display and therefore spent more time looking at the inanimate display, trying to extract some meaning. Since infants in our study were shown Scene A for a minimum of 45 seconds during habituation, they had ample time to explore all objects in the image. Even if infants were initially drawn to animate AOIs, after identifying and processing animate objects, they could have then moved on to visually explore other objects. If this were the case, we would not see significant differences in Interest across categories of AOIs.

Limitations and Future Directions

Many participants became bored easily and some did not complete all eight trials of our study. Using inattentional blindness videos akin to those used by Simons and Chabris (1999), instead of static images might be more interesting to infants. Simons and Chabris showed adult participants video clips of six people passing a basketball to each other. While the passing action continued, an unexpected event would occur, such as a woman in a gorilla suit walking across the court. Participants who were asked to count how many times the ball was passed failed to notice the woman in the gorilla suit. In a future study, children could be habituated to version A of a video and at test, version A’ would be shown with an animate or inanimate entity removed. If infants dishabituated at test, it would indicate that they noticed the change.

Further, while we ensured that AOIs were equal in size between the animate and inanimate category, we did not control for the location of the changing objects. Two of our inanimate AOIs (building and cup) were located at the forefront of the scene. Our animate AOIs tended to be located closer to the back of the scene. This could present a potential confound and should be controlled for in future studies.

Conclusions

Our results show evidence for an early-developing attentional preference for animate objects. By the age of 11 months, infants dishabituate significantly more often for changes to animate compared to inanimate objects. This finding agrees with adults' faster and better detection rates for animate changes in New and colleagues' (2007) change-blindness paradigm. Infants, like adults, seem to prioritize attention to animate entities and this result cannot be explained by familiarity.

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Chapter 4: Early Attentional Capture of Animate Motion: 4-Year-Olds Show a Pop-Out Effect for Chasing Stimuli

Hofrichter, R., & Rutherford, M.D. (2019). Early Attentional Capture of Animate Motion: 4-Year-Olds Show a Pop-Out Effect for Chasing Stimuli. *Perception*, *48*(3), 228-236. https://doi.org/10.1177/0301006619828256

Preface

Humans are social animals and constantly monitor their environment for other animals. We are very good at distinguishing between animate agents who are alive and inanimate objects who are not (New, Cosmides & Tooby, 2007). One way to identify animate agents is based on the way they move. People's movements provide information about their intentions and their goals (Satori, Becchio & Castiello, 2011; Cannon & Woodward, 2012). Adults not only ascribe intentions to humans and non-human animals but also to geometric shapes that move as if they were alive (Heider & Simmel, 1944; Premack & Premack, 1995; Tremoulet & Feldman, 2000). When adults are shown computer displays of geometric shapes engaging in interactions, such as fighting, participants attribute goals and intentions to the shapes and seem to be unable to define their movements in strictly physical ways (Rochat et al.,1997, Scholl & Gao, 2013; Heider & Simmel, 1944; McAleer & Pollick, 2008).

In the environment in which our species evolved, it would have been essential to quickly pick out predators in our surroundings because they pose a potential threat (New, Cosmides & Tooby, 2007). We are frequently exposed to non-threatening animate motion, such as people walking down the street and squirrels climbing up trees. Therefore, not all types of motion should be equally effective at capturing attention. However, a predator chasing its prey should capture attention, as it may indicate a threat.

Chasing displays have been widely used in animacy detection studies, both with adult participants (Meyerhoff, Schwan & Huff, 2014, Scholl & Gao, 2013) and child participants (Rochat et al., 1997; Rochat et al., 2004; Galazka & Nyström, 2015; Galazka et al, 2016).

Studying chasing motion allows researchers to investigate both animacy detection and social attribution in one task. Chasing motion combines multiple animacy cues that individually capture attention. *Acceleration* is a strong cue to animacy as stimuli that accelerate appear to be self-propelled (Frankenhuis et al., 2013). *Heat-seeking*, pursuing a target without wavering from the most direct path, is another attention grasping feature of chasing. (Frankenhuis et al., 2013, Galazka & Nyström, 2015). *Interobject spacing* has also been shown to guide visual attention (Meyerhoff, Schwann & Huff, 2014). The closer the chaser gets to its target, the smaller is the interobject spacing. Across these cues, a study by Frankenhuis and colleagues (2013) showed that acceleration by itself captured almost as much attention as chasing. This could mean that acceleration is the feature that draws our attention to chasing (Lachter, Forster & Ruthruff, 2004, Treisman & Gelade, 1980) but the combination of features listed above gives chasing its social meaning.

Attention towards animacy is apparent early in life. Even 6-week-old infants selectively attend to face-like objects (Mondloch et al., 1999). However, this early attentional bias towards animacy does not necessarily imply that children at this age already interpret stimuli and motion cues as social and animate. Three-month-old infants show a preference for animate over inanimate motion (Rochat et al., 1997) but it is not until 8-10 months that children understand the social contingencies underlying chasing, as indicating by reliable dishabituation to role reversal of chaser and target (Rochat, Morgan & Striano, 2004). Therefore, initial interest in animate stimuli might be a precursor rather than a part of the same psychological construct as a later, more refined understanding of animacy that seems to emerge towards the end of the first year of life (Rochat et al., 2004, Cannon & Woodward, 2012, Baldwin & Sage, 2013). Even though young infants already show sensitivity towards animacy cues (Rochat et al., 1997), further research is needed to determine how this early interest in animacy is linked to older infants' concept of animacy (Galazka & Nyström, 2015) and to that of preschool children (Weisman et al., 2015). The current study aimed to determine whether 4-year-old children visually attend to chasing motion and attribute social meaning to moving shapes. Participants were presented with displays of a chasing dot pursuing a target dot, surrounded by randomly moving distractor dots. They were asked to identify the chasing dot by touching it on screen. Our results showed that 4-year-old children can visually and physically pick out a chasing agent among distractor dots and reaction time was independent of number of distractors present. Four-year-old children show a pop-out effect for chasing objects.

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Abstract

Preferential attention to animate motion develops early in life, and adults and infants are particularly attuned to chasing motion. Adults can detect chasing objects among up to 10 distractors and are better at detecting a chase among nonchasing distractors than a nonchase among chasing distractors. We tested whether an attentional preference for chasing has developed by the age of 4, and whether 4-year-olds can explicitly point out chasing objects. On a touch screen, participants were shown a chasing pair of circles among a varying number of distractors (2,4,6,8,10). Participants had to touch the chaser. Reaction time for adults or 4-year-olds was independent of distractor numbers, consistent with a pop-out effect for chasing stimuli. As early as 4 years of age, children show a pop-out effect for chasing objects and can identify them via touch.

Keywords: animacy, chasing, pop-out, social attention

Introduction

Humans perceive biological motion as animate (Johansson, 1973) and allocate attention selectively to animate stimuli (New, Cosmides, & Tooby, 2007). Even simple geometric shapes can be perceived as animate and goal directed (Heider & Simmel, 1944; Premack & Premack, 1995; Tremoulet & Feldman, 2000), and participants viewing displays of animated shapes seem unable to describe their movements without anthropomorphic terms (Scholl & Gao, 2013). It has been suggested that animacy detection is a specialized, automatic, irresistible process (Rutherford, 2013; Scholl & Gao, 2013).

Function of Attention to Animacy

Animate stimuli would have been consequential in evolutionary environments as rapid detection of predators would have been essential to survival. This biological relevance would have created a selection pressure for a human observer to be biased toward perceiving potentially animate stimuli as animate. Evidence of preferential attention to animacy includes research showing that adults are faster at detecting the presence of animate motion than determining that animate motion is absent (Meyerhoff, Schwan, & Huff, 2014a). Furthermore, in a change-detection paradigm, participants detect changes in animals more quickly than changes to objects (New et al., 2007). If animals are a nonchanging part of the image used in a change detection paradigm, participants are slower to detect changes to inanimate objects, likely because attention is captured by the animal rather than the element that is changed (Altman, Khislavsky, Coverdale, & Gilger, 2016).

Early Attention to Animacy and Chasing Detection

Visual attention to animacy develops early in life (Fantz, 1963). Three-month-old infants, like adults, interpret biological motion as animate (Bertenthal, Proffitt, & Cutting, 1984; Schlottmann & Ray, 2010). Furthermore, young infants have a strong preference for looking at chasing motion over noninteractive movement (Frankenhuis, House, Barrett, & Johnson, 2013; Rochat, Morgan, & Carpenter, 1997). By the age of 8 to 10 months, infants understand the social contingencies underlying chasing and can distinguish between the chaser and its target based on their movement (Rochat, Striano, & Morgan, 2004). Infants even have expectations regarding chase events: If infants see one agent chasing another agent, they expect the chaser to eventually catch the target (Wagner & Carey, 2005). We know that, starting in infancy, children preferentially attend to animate motion (Frankenhuis et al., 2013) and that they have some expectations about how animate agents should act (Rochat et al., 2004; Wagner & Carey, 2005). However, this does not mean that infants are already consciously aware of the differences between animate and inanimate entities. Even at the age of 5, children still struggle to determine whether plants fall into the category of things that are "alive", like animals. They do, however, group plants and animals together when they are cued with the category name "living things" rather than "alive" (Leddon, Waxman, & Medin, 2009). Children under the age of 10 also struggle to distinguish between mechanical motion of objects and intentionality and overattribute animacy to inanimate entities (Piaget, 1929). Furthermore, when asked to name things that are “not alive”, school-aged children tend to name entities that are dead, extinct, or imaginary rather than inanimate entities (Carey, 1985). Based on these findings, it seems that children show early attention to animacy (Frankenhuis et al., 2013) while their ability to describe differences between animate and inanimate entities is still developing. More research is needed to test when children form a concrete understanding of what is alive, and when they can communicate that understanding.

Cues for Animacy and Chasing Detection

Adults and children not only perceive real-life agents to be animate and to have intentions but also abstract shapes and inanimate objects that look like agents or behave in a goal-directed manner (Johnson, 2003; Rochat et al., 2004). Motion is an important cue to animacy. Tremoulet and Feldman (2000) found that changes in direction increased the likelihood that a figure would be seen as animate. Agents that accelerate are perceived as self-propelled (Frankenhuis et al., 2013), and speed alone in the absence of acceleration is a cue to animacy (Szego & Rutherford, 2007). Dots moving upwards in a computer display are perceived as more animate than dots moving downwards, likely because downward movement could be attributed to gravity (Szego & Rutherford, 2008). Chasing motion is a strong cue to animacy. An agent heading directly toward its target in a heat-seeking fashion, without wavering from its path facilitates the detection of chasing (Frankenhuis et al., 2013; Gao, Newman, & Scholl, 2009; Gao & Scholl, 2011). Furthermore, the shorter the distance between chaser and target is, the easier it is to detect chasing (Meyerhoff, Schwan, & Huff, 2014b). Participants are significantly faster and better at detecting a chasing object than a target object, likely because the chaser is the agent who initiates the interaction (Meyerhoff et al., 2014a; see also Galazka & Nyström, 2015).

Attentional Pop Out of Chase Scenes

According to Treisman and Souther (1985), attentional pop-out occurs when the search time for a visual stimulus is independent of the number of distractors in a display. If an object is distinct from distractors, it will stand out and can be detected via parallel search rather than serial search. This means that objects in the display can be processed simultaneously and search time is independent of the number of distractors, presumably because the target object “pops out” and captures the observer’s attention. In contrast, if an object is not perceptually distinct from the distractors and does not stand out, objects in the display need to be searched serially, one at a time. Across trials, average search time will be determined by the number of distractors. Parallel search which is set-size independent results in a flat search slope, while serial search results in a steeper slope with search times increasing as numbers of distractors do. Therefore, if search time is independent of the number of distractors, this is taken as evidence that the target object has captured the observers attention, or popped out (Treisman & Souther, 1985).Visual pop-out effects can be detected in infants as young as 3 to 4 months old (Colombo, Ryther, Frick, & Gifford, 1995). Meyerhoff et al. (2014a) showed that when a chasing pair of circles was shown among an increasing number of distractors, participants were still able to quickly detect the chasing pair, even with 10 distractors present. In addition, adults are better at detecting a chase among nonchasing distractors than a nonchase among chasing distractors (Meyerhoff et al., 2014a). Although Meyerhoff et al.'s (2014a) results did not show a pop-out effect, their results suggest that chasing stimuli draw more attention than nonchasing stimuli.

The Current Study

This study investigates an attentional sensitivity for chasing stimuli in adults and 4-year-olds. This study was designed to determine whether, by the age of 4, children not only visually attend to animate stimuli but can also explicitly point them out among distractors. We chose 4-year-old children as our participants because our task requires both verbal comprehension and fine motor skill levels that younger children lack. We wanted to test for evidence of an explicit understanding that would not be provided by a looking-time paradigm. Participants were asked to identify the chaser among an increasing number of distractors. Both children and adults responded via touch screen. The study tested the prediction that the reaction time for detecting chasing stimuli would be independent of distractor numbers which is consistent with a pop-out effect.

Methods

We confirm that data collection complied with current American Psychological Association Ethical Principles of Psychologists and Code of Conduct and that all measures, manipulations, and exclusions in the study are disclosed.

Participants

There were two groups of participants. Thirty-one undergraduate students (18 women and 13 men; *M* =18.67, range = 18–23) participated in exchange for course credit. Thirty-seven 4-year-old children (17 girls and 20 boys; *M* = 4.09, range = 3.99–4.25) were recruited through an existing research data base. Parents and their children were compensated for their time with $10. All participants had normal or corrected-to-normal vision.

Stimuli

The stimuli set consisted of black circles (RGB colour = 0,0,0) on a green (RGB colour = 46,139,87), 34cm x 19cm background. All circles had a diameter of 0.9cm.

During experimental trials, a pair of circles (chaser and target) was presented among a varying number of distractor circles (0,2,4,6,8,10). Performance on zero-distractor trials served as an inclusion criterion, and established baseline performance.

The distractors and the target moved around the screen following a trajectory determined by an algorithm that selected a random starting point (random selection of X and Y coordinates) and then, after following a randomly selected path length, initiated a turn of a randomly selected angle.

The target's initial position was randomly generated and the chaser's starting point was generated randomly but with the requirement that it was at least 250 pixels away from the target. The chaser traveled at a speed of 0.5 pixels per frame (ppf) and the target traveled at 0.495 ppf. Distractors' speeds ranged from 0.495 – 0.5 ppf. During each trial the chaser pursued the target in a heat-seeking fashion. The computer compared the X and Y coordinates of the chaser to those of the target, then adjusted the chaser's coordinates to reduce the distance between the two circles. If the distance between chaser and target dropped below 100 pixels, the target would temporarily accelerate (increasing speed by 0.005 ppf) until a minimum distance of 100 pixels was restored. Then the target returned to its original speed. To disguise this acceleration, individual distractor circles that started the trial at a slower speed (0.495 ppf) would temporarily accelerate (increasing speed by 0.005 ppf) at varying time points throughout the trial and then return to their original speed. If circles collided with boundaries of the screen the angle of their path changed such that they appeared to be deflected by the edge of the display. The display was created using Python and Open Sesame 2.9.5 Software. Stimuli were presented on a 12.3" Microsoft Surface Pro 4 touch screen, running Windows 10 operating system, with a refresh rate of 60 Hz.

Procedure

Participants sat at a table with the touch screen presented flat on the table in front of them. Their eyes were approximately 50 cm from the screen. Adults were asked to find the chaser and identify it by touching it on the screen. Once the chasing agent had been identified, the next trial would start. If there was no response within 15 seconds, the experiment would advance to the next trial.

For child participants, the touchscreen was placed inside a frame that was meant to evoke a meadow and they were told a cover story to make the study more interesting and child appropriate: They were told to imagine that the dots on the screen were sheep walking around in a field. One of the dots was a wolf chasing a sheep, trying to catch it. The experimenter asked the children to help catch the wolf by touching it on the screen. During child sessions there were pauses after every trial allowing the experimenter to judge whether the child was still attending to the task. If the child was still engaged, the experimenter would start the next trial immediately. However, if the child was tired or distracted, the experimenter allowed a short break. Then, the experimenter would turn the child's attention back towards the screen and reiterate instructions before proceeding to the next trial. Instructions for both groups included anthropomorphic statements, suggesting that the chaser was an animate agent.

The experiment started with six practice trials (one trial per condition) followed by 90 experimental trials (15 trials per condition) for adults and 30 experimental trials for (5 trials per condition) for children. The number of experimental trials was reduced for children to accommodate for their limited attention capacity. The order of trials was randomized for each participant.

Results

Data of twelve adult participants were excluded due to experimenter error (3), computer failure (4) or performance below the 50% accuracy cut-off in the zero-distractor condition (5). The data of four 4-year-old participants was excluded due to performance below the 50% accuracy cut-off in the zero-distractor condition.

A two-way repeated measures Analysis of Variance (ANOVA) was conducted using reaction time as a dependent variable, age of participants was a quasi-independent variable and number of distractors a within-subject independent variable. Only reaction times from trials in which participants successfully identified the chaser were included in the analysis (see Table 1) The ANOVA revealed a main effect of age: adult participants completed trials significantly faster (M=4816ms, SD=2544*)* than 4-year-olds (M=5167ms, SD=3092, $F(1,34)= 6.87$, $p< .013$). There was no main effect of number of distractors ($F(1,34)= 3.11$, $p> .05$): Figures 1 and 2 show reaction times as a function of number of distractors. There was no significant Age by Number of Distractors interaction ($F(1,34)= .806$, $p> .05$).

Table 1.

Adults' versus 4-year-old's mean accuracy across number of distractors

	2		4		6		8		10	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Adults	91.81	2.11	90.06	2.29	90.64	2.23	84.21	2.8	86.55	2.61
Children	40.74	4.24	37.78	4.19	35.56	4.14	32.59	4.05	20	3.46

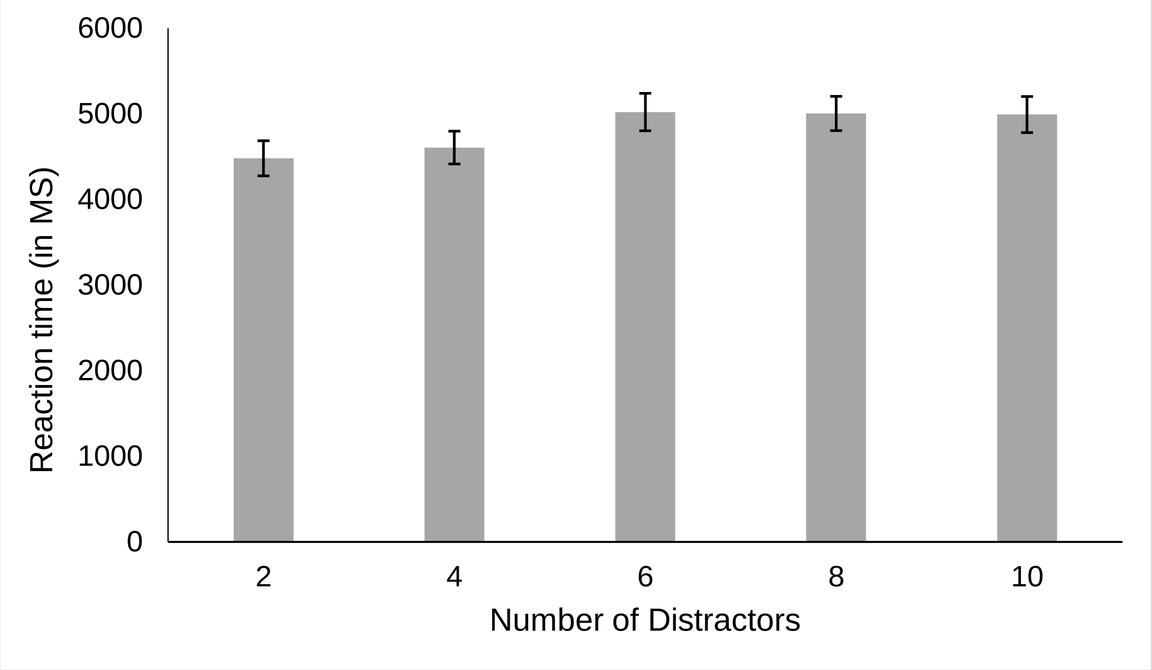

Figure 1. Adults' mean reaction times across number of distractors (in MS). Error bars represent SEM.

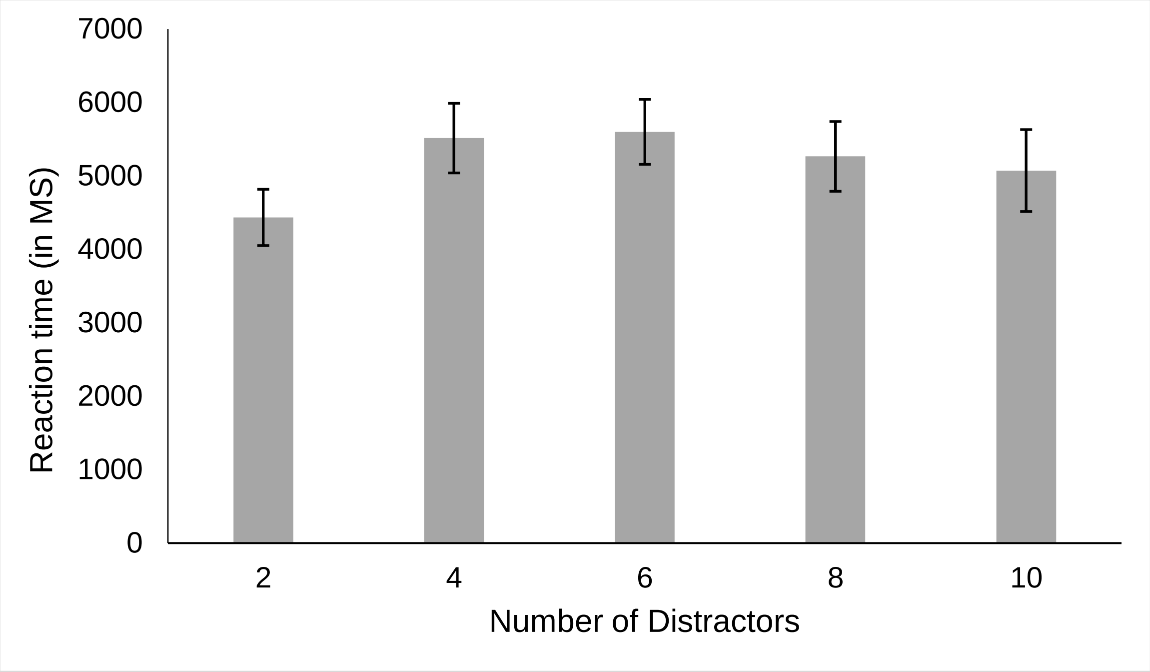

Figure 2. 4-year-old's mean reaction times across number of distractors (in MS). Error bars represent SEM.

Discussion

Our results provide evidence of a pop-out effect for animate motion. There were no significant differences in reaction time across trials with different numbers of distractors. Reaction time was independent of the number of distractors in the display which suggests that participants were able to process objects in parallel. This is consistent with a pop-out effect. If the chasing circles did not pop out, participants would have to conduct a serial search for the chaser from among all of the circles on the screen, yielding a linear relationship between number of distractors and search time, as more circles needed to be inspected and eliminated from consideration in higher distractor trials (Treisman & Souther, 1985).

Overall, our results are in line with previous research suggesting that animate objects in motion are special and are attentionally and perceptually prioritized over inanimate objects (Frankenhuis et al., 2013, Rochat et al., 2004; Scholl & Gao, 2013). Furthermore, our participants were proficient at detecting the chaser among up to 10 randomly moving distractors which adds to research reporting that humans process animate objects very efficiently (Altman, Khislavsky, Coverdale, & Gilger, 2016; New et al., 2007, Pratt et al., 2010).

Although both the current results and Meyerhoff et al.'s (2014a) results suggest that animate motion stand out among random motion, the two differ. Here, we found no significant increase in reaction time across conditions, indicative of a pop-out effect, while Meyerhoff et al.'s data showed a linear trend between reaction time and number of distractors. The steeper search slope in Meyerhoff et al.'s study suggests that participants needed to inspect objects serially, suggesting that the target did not pop out. These differences in results could be due to different response interfaces to record participants' responses. Although Meyerhoff et al. required participants to stop the display via key press and identify the chaser via mouse click, we simply asked participants to touch the chaser on the screen. This simpler procedure might have been more intuitive for participants, leading to quicker response latencies.

Furthermore, interobject spacing was not controlled for in our study. The chaser pursued its target in a heat-seeking fashion, consistently decreasing the distance between the two objects. All stimuli in our displays had randomly generated starting points, and distractors' movements were not based on the target's movements. Distractors would often come within close proximity of the target but, on average, did not stay as close to the target for prolonged periods of time as the chaser did. Research by Meyerhoff et al. (2014b) showed that close interobject spacing itself attracts attention as it signals interaction between stimuli. This is a variable that could have led to differences in results between our study and Meyerhoff et al. and should be controlled for in future studies.

An attentional bias toward animacy appears early in life with infants showing more interest toward animate than inanimate motion (Rochat et al., 2004). Children can distinguish between these different types of motion and, like adults, attribute agency to abstract shapes (Schlottmann & Ray, 2010). Children's ability to detect animacy has been demonstrated indirectly through eye-tracking (Frankenhuis et al., 2013), but there is a gap in the literature regarding children's ability to overtly identify animate agents. Our study fills this gap by demonstrating that children are not only attuned to animate motion and detect it quickly, but they can also point the chaser out among distractors in a moving display.

Adults' reaction times were significantly faster than those of 4-year-olds which is not surprising. This task involves visual tracking of objects and fine motor skills of touching a moving object on a screen, skills for which we would expect an adult advantage.

Limitations

Based on our findings, it is unclear when children first develop the ability to detect and overtly identify a chaser. It might be before the age of 4. Eight to 10-months-olds are sensitive to social contingencies of chasing and can distinguish between the chaser and its target (Rochat et al., 2004). Thus, it is possible that children younger than our participants would be able to detect the chaser among the randomly moving distractors. Further research with age-appropriate tasks would be needed to test when children are first able to explicitly point out a chasing object.

Adding a control condition could potentially strengthened the study. One possibility would be to task participants with locating a target among distractors that we would not expect to “pop out.” This would have allowed us to compare data from the chasing condition to the control condition and test for possible differences in reaction time. That said our finding of no relationship between reaction time and distractor set-size is sufficient as support for a pop-out effect.

Furthermore, in our study, reaction time scores encompass both visually identifying and physically contacting the target. Typically, reaction time in search tasks is measured by tasking participants to stop the moving display via key press as soon as they detect the target. They then physically identify the target in a second step that is not included in the reaction time measure (e.g., see Meyerhoff et al., 2014a). We decided to omit this two-step process to simplify the procedure for our 4-year-old participants. The task was already challenging for children and they struggled with the coordination of visually tracking the chaser and the fine motor movement of touching the target on the screen. This is reflected in their low accuracy rates. Low accuracy rates for 4-year-olds do not necessarily indicate that children did not see the chaser but are more likely a result of the high visual-motor integration demands of the task and fatigue. As a result of our attempts to simplify the task for children, our reaction times might differ from other studies that measure visual and physical identification separately.

Conclusions

Our results show evidence for a pop-out effect for chasing motion among inanimate distractors in both adults and 4-year-olds. Reaction times across age groups were independent of the number of distractors added to the display. By the age of 4, animate chasing motion stands out among randomly moving distractors and children can successfully identify the chaser both visually and via touch.

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Chapter 5: Conclusions

The series of experiments included in this dissertation were designed to examine humans' specialized processes involved in social perception. Social perception allows us both to identify social agents and to interpret their thoughts and intentions. This ability is adaptive as humans rely on social interaction. In addition, fast and efficient identification of dangerous agents, such as predators, would have increased survival in evolutionary settings. Because social perception underlies all human interaction, we were interested in studying the phenomenon in different age groups. Participants in our studies included adults (Chapter 2), preschool-aged children (Chapter 3), and infants (Chapter 4). Specialized processing of social stimuli is already apparent in infancy and into adulthood, underscoring its importance.

Summary of findings – Chapter two

In Chapter two, we found that if human bodies are sexualized, they are perceptually objectified. Sexualization seems to impair the processing of bodies as social stimuli and instead facilitates the processing of bodies as objects by the visual system. In experiment one, we replicated the findings of Bernard and colleagues (2012) while controlling for possible low-level confounds in their stimuli set. They had reported an inversion effect for sexualized male body images, as would be expected for social stimuli, but no inversion effect for sexualized female body images. Both image sets (male and female) presented models wearing only swim suits or underwear and posing in a suggestive manner.

However, these results indicate that only female bodies were perceptually objectified. These results suggest that the threshold for sexualized female bodies to be objectified is lower than for sexualized male bodies. Despite the fact that male bodies were also minimally clothed, they were still processed as social stimuli. This was the case for both male and female observers viewing the images.

We are used to seeing female bodies presented in a hypersexualized manner in the media (Archer, Iritani, Kimes, & Barrios, 1983). Fredrickson and Roberts (1997) argued that, in western society, we have come to internalize the perspective of the female body being valued for its use and as something to be looked at by others (Wright, Arroyo, & Bae, 2015). It is possible that this greater focus on women's physical traits than on their mental abilities or subjective experience leads to women being seen as sexual objects rather than as people, and as a result, we perceptually objectify these stimuli more readily than sexualized male bodies (Bernard et al., 2012; Fredrickson & Roberts, 1997).

Experiment two was motivated by the questions of whether perceptual objectification can be manipulated (increased or reduced) and whether it is exclusive to female bodies. Previous research suggested that providing participants with humanizing information about targets regarding their occupation and concern for others resulted in an inversion effect for sexualized female bodies (Bernard, Gervais, Allen, Delmée, & Klein, 2015). Further, research by Bernard and colleagues (2019) indicated that suggestive body postures led to both male and female targets being perceptually objectified. We were interested to see if similar effects could be achieved by manipulating levels of sexualization using audio files. While Bernard and colleagues (2015) assigned participants to either a neutral or humanizing condition and provided written information about a group of targets, we matched each target with a different audio file, each conveying either high or low sexualization information about their dating or sexual history. We used the same stimuli set as in experiment one to facilitate a direct comparison of results.

Like Bernard and colleagues (2015), we found that targets matched with low sexualization audio files were processed as social stimuli. In contrast, targets matched with high sexualization information where perceptually objectified. This was the case regardless of whether the target was male or female. Both Bernard and colleagues' study (2015) as well as our results indicate that providing humanizing information reduces perceptual objectification of female bodies. Our findings add to those of Bernard and colleagues (2015) but are novel as we did not assign participants to conditions but varied high versus low sexualization information within participants. Our results suggest that audio files were effective at impacting how participants visually processed targets and that the switch from perceptually objectifying a target to processing a target as a social stimulus can happen rapidly, from one trial to the next. Our results are also in line with Bernard and colleagues (2019) who showed that both male and female targets can be perceptually objectified. Therefore, perceptual objectification does not seem to be limited to female bodies but can be induced for male bodies. While we readily perceptually objectify sexualized female bodies (Bernard et al., 2012), it seems that male bodies require higher levels of sexualization to be perceptually objectified.

Future directions - Chapter two

It is important to note that we exclusively recruited participants who identified as heterosexual. Further research is required to determine whether sexual orientation might impact perceptual objectification. Previous research suggested that gay or bisexual men experience more body dissatisfaction, body surveillance, and social physique anxiety after being exposed to media images of muscular men (Michaels, Parent, & Moradi, 2013). Media aimed at gay men contains more images of muscular sexualized male bodies (Harvey & Robinson, 2003) and gay men are more likely to self-objectify than heterosexual men (Martins, Tiggemann, & Kirkbride, 2007). Therefore, it is possible that gay men viewing the sexualized male bodies in our study would be more likely to perceptually objectify them than our heterosexual male participants.

Summary of findings – Chapter three

In chapter three, we discovered that 11-month-old infants are more likely to detect social stimuli, including humans and animals, than objects after one of these two object types was removed from an image of a natural scene. This result suggests that infants, like adults, prioritize attention to living agents over inanimate objects (New, Cosmides, & Tooby, 2007). Our findings agree with previous studies that have shown that infants orient to animacy. Even newborn infants show a preference for face-like stimuli over non-social control stimuli and turn their head and eyes to look at these social stimuli (Fantz, 1963; Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991). This preference cannot be due to experience or familiarity with faces or agents and has therefore been suggested to be an evolved preference (Goren et al., 1975).

Likewise, the performance advantage in our study for change detection involving animate objects cannot be explained through familiarity or expertise. Changing inanimate objects in our study included common household objects like a TV and a cup, things with which most children would be familiar. Animate objects that disappeared, on the other hand, included a horse and a lion. If familiarity was driving the effect, children should be performing better for items like the TV and the cup than for the horse and the lion. In contrast, a change detection study with adult participants showed that individuals with expertise in American football were more likely to detect changes in football related images, compared to football novices (Werner & Thies, 2000). Here, expertise seemed to make participants more sensitive to occurring changes. New, Cosmides and Tooby (2007) suggested that the detection advantage for animate, living agents, in their adult study was likely due to their evolutionary significance. An evolutionary pressure to monitor animate agents is consistent with our pattern of results. To test more explicitly for attention guided by evolutionary pressures, future studies could compare change detection for targets within the animate category. Previous research has shown that children can distinguish between threatening and non-threatening animate agents (Hoehl, Hellmer, Johansson, & Gredebäck, 2017; LoBue, 2010). If infants' attention is guided by evolutionary pressures, we would expect to see a performance advantage for detecting threatening animals, such as a spider or a lion, being removed from scenes compared to non-threatening animals, like a fish or a bunny.

Our study is unique as most previous studies on infants' attention toward animacy focus on animate motion (Frankenhuis, House, Barrett, & Johnson, 2013; Rochat, Morgan, & Carpenter, 1997; Schlottmann & Ray, 2010; Woodward, Phillips, & Spelke, 1993). In contrast, our study used static images of complex naturalistic scenes. To our knowledge, our study is one of the first to use a visual change-detection paradigm with infants. We adapted the change-detection paradigm used by New, Cosmides and Tooby (2007) for use with infants. While adults in the original study pressed a button to indicate they had figured out the change, our infant participants could not overtly answer our research question by pressing a button or responding verbally. Therefore, we used habituation and eye tracking. These are methods commonly used in infant research (Frankenhuis et al., 2013; Rochat, Striano, & Morgan, 2004). Using these methods, we were able to advance the field by building on the previous finding of adults being more efficient at detecting animate changes (New et al., 2007) and replicating this finding with infants.

Future directions - Chapter three

One possible confound in the current study was low-level differences between images of scenes, such as variance in luminance and complexity. New and colleagues (2007) tested whether such low-level visual characteristics predicted performance. They did not find any significant effects. However, although we used the same stimuli as New and colleagues, we did not control for these low-level characteristics in our analysis, so we cannot say for certain whether they presented a confound in our study. It is possible that adults and infants were affected differently by low-level features. One way to account for this possible confound in future studies would be to create a new stimulus set and use the same background across animate versus inanimate trials. For example, the same garden background could be used for an animate trial where a cat is the changing element and an inanimate trial where a watering can is the changing element. Therefore, lower-level information would be constant across animate versus inanimate trials and performance differences should be due to the category of the changing element. Further, future studies could track and analyze children's eye movements throughout the entire task. It would be interesting to compare exploration patterns for animate versus inanimate trials, rather than just compare looking time towards AOIs.

Summary of findings – Chapter four

Chapter four revealed that 4-year-old children are efficient at detecting a chasing agent among inanimate distractors and show a pop-out effect for chasing motion. Our findings add to the existing literature that has shown that even newborn infants prefer looking at biological, animate motion compared to random, inanimate motion (Bardi, Regolin, & Simion, 2011). This preference for animate motion is not uniquely human. Newborn chicks also prefer biological over random motion (Regolin, Tommasi, & Vallortigara, 2000). Humans' preference for animate motion persists throughout infancy (Fox & McDaniel, 1982), throughout childhood (Lee, Aoki, Stefanov, Yamamoto, & Obinata, 2016), and into adulthood (Meyerhoff, Schwan, & Huff, 2014).

Our study offers a novel contribution to the literature as it requires children to explicitly point out and identify a chasing agent. Most studies investigating young children's understanding of animacy use eye tracking (Frankenhuis et al., 2013), habituation (Rochat et al., 2004) or preferential looking paradigms (Rochat, Morgan, & Carpenter, 1997). These methods are used to determine whether young children can distinguish between animate and inanimate motion and whether they show a preference for one over the other. Even before children develop a sophisticated sense of agency, infants 3-4 months of age show a preference for motion that indicates that an agent is alive (Frankenhuis et al., 2013; Rochat et al., 1997). Children at this age are unlikely to interpret animate movements in a goal-directed, social manner. Instead, their attention has been suggested to be guided by an adaptive bias towards animate information (New, Cosmides & Tooby, 2007, Simion, Bardi, Mascalzoni & Regolin, 2013). Towards the end of the first year of life, brain activity indicates that infants process chasing motion as social but not random motion (Galazka, Bakker, Gredebäck, &

Nyström, 2016). This suggests that by this age children have developed a more explicit understanding of animate motion (Galazka et al., 2016; Rochat et al., 2004). As children grow older, they can overtly answer questions about their beliefs regarding animate motion. School-aged children who are shown displays of animate motion tend to ascribe anthropomorphic characteristics to the motion (Galazka et al., 2016; Rochat et al., 1997; Poulin-Dubois & Heroux, 1994). Our study stands out as, to our knowledge, it is the first study that goes beyond measuring children's eye movements or brain activity while they passively watch or asking children to verbally describe animate displays. Our study requires children to distinguish animate agents from inanimate distractors, visually track the animate agent while they are in motion and physically touch the agent to identify it.

Our study is also unique as it is an adaptation of Meyerhoff and colleagues' (2014) chasing detection study run with adult participants. We used a touch screen to make the study child friendly and ran the paradigm with adult participants first to confirm that adults would interpret our displays as we intended. Adapting a study previously run with adults, and running both adult and 4-year-old participants allowed us to compare performance across two studies and between our age groups. Our results revealed that by the age of 4, children, like adults, show a pop-out effect for chasing agents.

Future directions - Chapter four

Children's ability to detect and interpret agency cues has been studied extensively and across various ages (Galazka et al., 2016; Rochat et al., 1997; Poulin-Dubois & Heroux, 1994). Different paradigms have been used according to each age group's capabilities and to adjust cognitive demands appropriately. These differences between paradigms make it difficult to compare results across studies and ages and to determine whether they measure the same construct. In the future, it might be helpful to run a longitudinal study investigating children's perception of animate motion that combines indirect (e.g. eye tracking, habituation) and direct measures of animacy attribution (e.g. physical identification of agents, verbal description of displays). This would allow us to establish a more cohesive developmental trajectory of children's animate motion perception.

Conclusions

In this dissertation, I examined humans' ability to distinguish between social and non-social information across different age groups and the specialized processes underlying social perception. Chapter 2 focused on the specialized mechanisms involved in processing bodies. Inverting images of bodies impairs our ability to process them but when bodies are sexualized, they are perceptually objectified. Chapters 3 and 4 showed that young children reliably differentiate between social agents and inanimate objects and prioritize attention toward social agents. Eleven-month-old infants detect changes to animate agents more efficiently than those to inanimate objects and by the age of 4, children do not only preferentially attend to animate agents but can also physically point them out among inanimate distractors.

Social perception is susceptible to contextual cues. Results from chapter two showed that visual processing of bodies was affected by information provided through audio files. These short audio files were effective at impacting whether a target was processed as a social stimulus or an object within participant and from one trial to the next. This suggests that in real life, our perception of others and how we process social stimuli can also be modulated by contextual cues, such as what another person looks like or what we have heard about them. Likewise, children, like adults, are consciously aware that dots on a computer screen are not alive and yet, chapter four reported that children perceived the dots to be chasing one another, based on motion cues. Both examples suggest that social perception is irresistible and happens fast from infancy onwards and throughout life. Identifying and processing social information is crucially important for us as social animals and therefore studying social perception and its development is vital.

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