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Toy story: Why do monkey and human males prefer trucks? Comment on “Sex differences in rhesus monkey toy preferences parallel those of children” by Hassett, Siebert and Wallen

Christina L. Williams* and Kristen E. Pleil

Department of Psychology and Neuroscience, Duke University, Durham, NC 27708, USA

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Parents of young children will tell you that boys like different toys than girls; they are intrigued by Bob the Builder, Transformers of all kinds, trucks, police cars, front loaders, bikes, skate boards, and wagons. Girls too like bikes, cars and Legos, but also play with stuffed animals and dolls, toys that boys find less appealing for active play. Is this difference in toy preference due exclusively to socialization by parents, other children, and the media, or are there basic perception/action differences between males and females that make some toys a better “fit” for or more attractive to one sex than another? In this issue, Hassett et al. (2008) provide evidence that male and female rhesus monkeys (*Macaca mulatta*) of all ages and ranks show preferences for wheeled and plush toys that resemble the preferences shown by human children in many studies of toy choice. This cross-species demonstration of male–female differences in toy choice strongly supports and extends prior work with humans (e.g., Berenbaum and Hines, 1992; Campbell et al., 2000; Pasterski et al., 2005; Serbin et al., 2001) and vervet monkeys (Alexander and Hines, 2002) showing that sexually dimorphic toy preferences reflect basic neurobiological differences between males and females and are not caused solely by socialization, as has been suggested by cognitive-social theories of gender role behavior (Caldera et al., 1989; Carter and Levy, 1988; Pomerleau et al., 1990; Roopnarine, 1986).

Despite repeated demonstrations of sex differences in toy choice that are difficult to explain by socialization alone (e.g. Alexander, 2003; Nordenström et al., 2002; Meyer-Balshberg et al., 2004; Pasterski et al., 2005; Serbin et al., 2001), there has been considerable resistance to the idea that toy choice/preference is influenced by genetics and hormones, in part, because the wheeled and mechanical toys that males prefer are not part of our evolutionary history. How could male brains evolve to prefer objects that did not even exist when our modern *Homo sapiens* brain was shaped by adaptive forces? What is it about toys that make them “male” or “female”? Toy preference is a complex cognitive process determined by sensory, perceptual and motor processes; what sexually dimorphic neural mechanisms control these differences? The findings of Hassett and colleagues have important implications for all of these issues.

What is the difference between boys' and girls' toy choice?

Previous studies have reported differences between males and females in toy choice; that is, girls generally favor toys such as soft dolls, whereas boys generally favor construction and transportation toys (e.g., Connor and Serbin, 1977; Liss, 1981; Pasterski et al., 2005; Roopnarine, 1986). We believe that this description of the findings fails to highlight another important and intriguing “within-sex” difference in toy preference, which is wonderfully illustrated in Hassett et al. (2008). As shown in their Fig. 1, when play time with toys is examined in human children (Berenbaum and Hines, 1992) and rhesus macaques of all ages, males spend significantly more of their play time with the “male” toy(s) than with the female toy(s), while females spend about equal times with “male” and “female” toys. This is true both for frequency of interactions and in time spent playing (Hassett et al., 2008). Therefore, one key difference between males and females in these studies is that males actually show a toy preference while females do not! A number of other studies of children's toy play and toy preference have reported similar pattern of toy choice with girls playing about equally with all types of toys and males showing a strong bias for male toys (e.g., Carter and Levy, 1988; Campbell et al., 2000; Serbin et al., 2001; O'Brien and Huston, 1985). Note, however, that other studies of toy choice in human children (e.g., Caldera et al., 1989; Pasterski et al., 2005; Pomerleau et al., 1990) and vervet monkeys (Alexander and Hines, 2002) find that females prefer female toys to male toys, suggesting that the methods of testing (e.g., presenting male and female toys simultaneously or sequentially), types of toys presented (e.g., dolls vs. trucks or cosmetics vs. weapons) and the socialization that occurs with age may, under some test conditions, increase female's interest in some toys. Our comments will be focused on the results of Hassett et al. (2008), which parallel some studies of human children. These data suggest that males show strong preferences for mechanical toys or strong aversion to plush toys, when they are asked to choose between two competing toys presented simultaneously, while females do not show this bias.

We know of at least two other examples of male–female cognitive differences that resemble the interesting pattern that appears in the toy choice data of Hassett et al. (2008): visual recognition memory (McGivern et al., 1997) and spatial navigation (e.g., Sandstrom et al., 1998; Williams et al., 1990; Williams and Meck, 1991). In both of these cognitive domains, females appear to process information comprehensively, while males appear to select and respond to only certain types of information. For example, when visual recognition memory for male-oriented objects (e.g., drawings of balls, bikes, sports equipment, and motor vehicles), female oriented objects (e.g., drawings of human and animal figures, cooking and sewing items, girls' clothing) or random objects (e.g., drawings of household items, office objects, furniture) was assessed in children and adults, females performed equally well when presented with all three types of stimuli, and males only performed as well as females when the objects were male-oriented (McGivern et al., 1997). These data are particularly striking because the authors ruled out a language-based explanation of their findings by including a more difficult task in which a single neutral object differed only in its internal pattern; thus, these objects would be difficult to name. While the performance of all subjects for this task was very poor compared to memory of nameable objects, females still outperformed males. These findings suggest that this sex difference in recognition memory may be the result of differences in visual attention. Male bias to attend to male-oriented objects may account for their increased performance only on this category of objects.

Males, but not females, also show strong selectivity in information processing of spatial information. When a navigation task may be solved by using either local or distal cues, male rats (e.g., Brown and Moore, 1997; Sava and Markus, 2005; Suzuki et al., 1980) and rhesus monkeys (Herman and Wallen, 2007) tend to use distal cues, while females are able to use either type of cue (Herman and Wallen, 2007; Tropp and Markus, 2001), suggesting that

females may be more likely to attend to both types of information while males focus on one type of cue. This difference can also be seen if rats' use of spatial information is probed after male and female rats reach equal asymptotic performance on a radial-arm maze task (Williams et al., 1990). Female rats are *not* disrupted in performance if either landmark (e.g., the computer, experimenter, cart with cages) *or* geometry (e.g., the rectangular room shape) is removed or obscured. However, males are completely reliant on room geometry; their performance is severely disrupted if the room shape is obscured, even if large salient landmarks in the room remain to guide navigation. In this case, it appears that for males, the Euclidian properties (i.e., angles and distances) that define the environmental landscape (e.g., test room) overshadow the large salient landmarks, and are the default information for spatial navigation, while females appear to process both environmental geometry and landmark cues comprehensively, and can use either set of cues to navigate. Interestingly, these effects are organized by perinatal hormone exposure, as males castrated at birth rely on both landmarks and geometry similar to adult ovariectomized females; and neonatally estrogen treated females show reliance on geometry, just like adult castrated males (Williams et al., 1990). Thus while circulating hormones may further alter navigation strategies (e.g., Korol, 2004), they are not required for these sex differences in cue use.

These examples highlight one of the major findings of Hassett et al. (2008) that for toy choice, information processing may be filtered in males. Wheeled toys command attention and their perceptual characteristics overshadow information coming from plush toys. Females do not filter information in this fashion, thus all toys are equally interesting.

Why do toys have gender?

It is difficult to understand why male rhesus monkeys, prefer “masculine” wheeled to “feminine” plush toys even though they have never encountered these toys previously. What perceptual information do monkeys (or humans) use to distinguish between male-preferred and female-preferred toys? Perhaps female monkeys are “programmed” to be social and maternal, and therefore, they are more likely to choose soft toys that can be groomed or held while males are active and prefer toys that move, however, this explanation does not fit the data presented. Females play with both active hard toys and soft cuddly toys, but males strongly prefer only the hard “wheeled” toys. Perhaps a better approach is to ask what features of the wheeled toys make them especially appealing to males. One possibility is that while both plush and wheeled toys can be used in active play (e.g., they can be thrown or jumped upon) only the wheeled toys show internal motion. Interest in object motion is apparent very early in development in males; infant boys show a looking preference for mechanical motion over biological motion, while infant girls show the opposite pattern (Lutchmaya and Baron-Cohen, 2002). Alternately, the angular wheeled toys may have different affordances for action than the plush toys. Soft surfaces may promote stroking while apertures on wheeled toys may produce a different sort of manual exploration. We know, for example, that the surface features of objects alter the way that very young infants guide their hands to novel objects, even before they have the motor coordination to execute a grasp (Barrett et al., 2008).

Hassett and colleagues suggest that sex differences in activity, with males showing high levels of rough and tumble play compared to females, may explain why males have a preference for toys that have wheels. This may be part of the reason for the reported sex difference, but it seems unlikely to be the only explanation. How would a monkey know that a toy has internal moving components until they interacted with the object? Campbell et al. (2000) have shown that 9-month-old human males have a visual preference for male-typical toys, while females show no preference, and both sexes prefer to look at male-type over female-type activities. And it is interesting that this same pattern of visual preference is seen in 18–22 year olds, with males showing more visual fixations on balls, trucks and robots presented on a computer screen

than on dolls or babies, while females do not show this bias (Alexander, 2006). Campbell et al. (2000) argue that this sex difference in attention to male and female-type toys cannot be a consequence of activity preference because the infants in their studies did not have prior physical interactions with the toys or activities they were viewing. While this does not exclude the possibility that action can affect perception, Hassett and colleagues do not provide data that would shed light on whether activity with the toys determines later preference or whether preference occurs prior to action. In toddlers, both boys and girls prefer toys that allow moderate to high activity (O'Brien and Huston, 1985), suggesting that boys do not select boy-type toys solely because they are action-eliciting. Further examination of this issue would be useful to tease apart an action interpretation from biased perception interpretation. We would argue that if a monkey shows a preference in initial contact, or in the length of time it looks at the object, the sex difference observed in toy choice is in some perceptual process that guides action. In contrast, if all monkeys initially manipulate both objects, even briefly, and only the preferred motor interaction is continued, then an action interpretation, which Hassett and colleagues support, may be the better explanation.

Sexually dimorphic brain mechanisms for toy choice?

The findings of Hassett and colleagues do not directly address the issue of mechanism, but the seminal work of Berenbaum and Hines (1992) revealed that girls who have Congenital Adrenal Hyperplasia (CAH) and have been exposed to high prenatal levels of adrenal androgen show a strong preference for male-type toys over female-type toys, compared to their unexposed sisters (see also: Meyer-Bahlburg et al., 2004; Pasterski et al., 2005). Thus, prenatal androgen exposure may produce a strong bias in exposed females such that they decrease their interest in female toys and increase their interest in male toys. CAH girls prefer male play styles (Berenbaum and Hines, 1992; Ehrhardt and Baker, 1974) and have enhanced spatial ability (similar to males) compared to their unexposed sisters (e.g., Resnick et al., 1986), suggesting that there may be a common hormonal mechanism underlying sex differences in these cognitive domains. While the complex involvement of social influences on toy preference of human subjects is always a factor, a primary role for organizational hormones in toy preference seems likely.

The issue that remains to be addressed is what is being organized by neonatal androgen exposure in males that leads to sex differences in toy preference. The possibility suggested by Hassett and colleagues is that brain mechanisms for rough and tumble play are masculinized by androgens early in development (Goy et al., 1988; Wallen, 1996), and high activity play behavior is somehow translated into preference for mechanical motion. This is certainly a possibility, though we know of no direct evidence that individual differences in activity levels are related to preferences for internally moving objects.

Alternately, perhaps testicular hormones organize sensory/perceptual systems differently in male mammals. The visual system, like many other sensory systems, shows sex differences in structure and function. For example, females prefer 'reddish' colors, whereas males prefer hues that are less reddish (Hurlbert and Ling, 2007). Whether organizational or activational androgens are able to modulate this difference is not known. But this finding may provide some insight into the results of a previous study (Alexander and Hines, 2002) that differed slightly from the results of Hassett et al. (2008). Alexander and Hines (2002) showed that female vervet monkeys (*Cercopithecus aethiops sabaesus*) spent more time playing with a doll and a pot (female-type toys) than with a car or ball (male-typed toy). The female-type toys in this study were reddish in color while the male-type toys were not. Thus, as was suggested by Alexander and Hines (2002), sex differences in color preference must be taken into consideration when interpreting toy preference data, as it may have a strong influence over toy choice that is not related to object type.

Alexander and Hines (2002) have proposed the interesting hypothesis that there may be as yet undiscovered sexual dimorphisms in the visual system for object location (dorsal stream) versus object perception (ventral stream) that contribute to sex differences in toy preference. In fact, sex differences have been shown at several levels of sensory processing. Retinal thickness is determined by prenatal androgen exposure in rats (Salyer et al., 2001) though it is not yet clear how thickness of retina alters function of the visual system. Hormones may also alter basic sensory processing, possibly by gating sensory input to cortical regions or by differentially inhibiting this input within cortical circuitry. One study examining sex differences in auditory system processing showed that, in males, background noise causes prefrontal suppression of primary auditory cortex, such that prefrontal attentional responses to music are enhanced. Females do not show this mechanism, suggesting that males may have brain mechanisms that allow focused attention to a single stimulus (Ruytjens et al., 2007). Another recent study (Tomasi et al., 2008) reported sex-specific differences in brain activation during a visual attention task that required tracking of multiple moving objects at different cognitive and acoustic levels, suggesting sex differences in auditory gating. Sensory gating likely occurs via thalamic neuron function (Ciancia et al., 1988; Schall et al., 1999), and is modulated by dopaminergic/glutamatergic circuits (Schall et al., 1999) involving the brainstem, hypothalamus, and cerebral cortex. Consistent with this hypothesis, androgen receptors are localized mainly on pyramidal cells in sensory and motor regions, most prominently in layers II/III and V/VI. Retrograde labeling shows a strong coincidence of androgen receptor-immunoreactivity with cells making cortico-cortical, and to a lesser extent cortico-thalamic, connections, which are both key circuit systems contributing to cortical information processing (Kritzer, 2004). Thus, one unexplored possibility is that androgens may act directly on cortical circuits to modulate gating of incoming sensory or outgoing motor information. Perhaps prenatal androgen exposure in males allows for strong inhibition of competing neuronal pathways leading to selective and persistent interest in wheeled toys; females may not have these androgen-induced gated circuits and thus they may be more likely to show comprehensive and parallel attention to multiple toy types.

The field of behavioral neuroendocrinology has made great progress in our understanding of the neurophysiological and hormonal modulation of sex differences in chemoinvestigatory choice behavior, particularly with regard to partner preference (e.g., Bakker et al., 1996); and these types of studies could serve as an excellent model for investigating the mechanisms underlying sex differences in emotion and complex cognitive processes like counting, timing, and toy choice (Cheng et al., 2008; Cordes et al., 2007; Droit-Volet and Meck, 2007).

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