
Neuroscience, Gender, and “Development To” and “From”: The Example of Toy Preferences

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Cordelia Fine

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Abstract

“Development to” perspectives implicitly or explicitly assume that experience influences the individual’s development “to” a genetically encoded phenotype. By contrast, “development from” perspectives assume no genetically pre-specified developmental pathway, but the co-construction of the phenotype from the complex and dynamic interaction between environmental stimuli, genotype, and the organization of the nervous system at each developmental phase. This chapter examines the “brain organization” account of sex differences in toy preferences in light of challenges to the “development to” perspective, of which the brain organization account is an example. It is argued that there are significant methodological and conceptual issues, and empirical uncertainties, regarding each of four categories of evidence commonly cited as support for the brain organization account. The scientific and

C. Fine

Melbourne School of Psychological Sciences & Melbourne Business School & Centre for Ethical Leadership, University of Melbourne, Carlton, VIC, Australia
e-mail: c.fine@mbs.edu

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ethical need for research from a “development from” perspective for future investigations of this politically important and socially sensitive scientific question is discussed.

Introduction

Persistent sex differences in social roles, occupations, and occupational success – even in progressive twenty-first century societies – is a phenomenon requiring explanation. As Eagly and Wood (2013) have recently noted, research within behavioral science that ultimately seeks to answer this question has mostly taken place in parallel streams. On the one hand, there are researchers interested in the influence of social factors (such as gender socialization and sex-based discrimination), while others investigate the contribution of biological factors (such as the effect of hormonal and brain differences between the sexes). The conceptual framework for the latter group of researchers is often (either explicitly or implicitly) the prominent and influential “brain organization” theory (for brief overview, see Breedlove et al. 1999; Hines 2010). During gestation, the gender-directed development of testes in the male fetus results in a surge of gonadal fetal testosterone (fT), and this directs the development of male genitalia. In humans, this “critical period” occurs during approximately weeks 8–24 of gestation (Reyes et al. 1973). Brain organization theory, first proposed by Phoenix and colleagues (Phoenix et al. 1959), holds that a second effect of this surge of fT is to permanently “organize” a male brain that produces male behavior (in some cases, after these brain structures are activated by circulating sex hormones in pubescence and adulthood).

Brain organization theory was originally proposed to explain sexually differentiated behavior, particularly behavior tied to reproduction, in nonhuman animals, but it has since been proposed that the organizational effects of fetal testosterone on brain development contribute to human sex differences in sexuality, gender identity, and gender-typed interests (e.g., Hines 2010, 2011; for comprehensive review and critique, see Jordan-Young 2010). Proponents of such brain organization accounts of course acknowledge that social experiences contribute to human sex differences. However, social experience is often implicitly or explicitly represented as playing a merely influential, amplifying, or even interfering role in development, rather than an integral one as co-author of the developing phenotype. Moore (2002) has provided a helpful articulation of the distinction between these differing perspectives, referring to them as “development to” and “development from” approaches, respectively. In the “development to” perspective, there is an underlying assumption that experience merely influences the individual’s progress “to” a genetically encoded phenotype. By contrast, according to a “development from” perspective, there is no pre-specified developmental pathway. Rather, every developmental step is constructed from the complex and dynamic interaction between environmental stimuli (including social experiences), genotype, and the organization of the nervous system in a particular developmental phase.

A “development from” approach, with bidirectional genetic, hormonal, neuronal, behavioral, environmental, and cultural influences, is supported by research across each level of analysis of behavior (Li 2003; Lickliter and Honeycutt 2003). This has important implications for neurobiological investigations of sex differences: Gender, as a powerful and pervasive social phenomenon, has material effects on the body and brain (e.g., Fausto-Sterling 2005; Kaiser 2012). One recent example is provided by a large-scale longitudinal study, which found that fatherhood reduced testosterone levels in men. This reduction was greater in fathers who spent more time physical caring for their young offspring (Gettler et al. 2011). The influence on endocrine state of the social construction of gender roles for fathers, in terms of expected contribution to parenting, is also indicated by a comparison of two neighboring cultural groups in Tanzania, which found lower testosterone levels among fathers from the population in which paternal care was the cultural norm, than in fathers from the other group in which paternal care was typically absent (Muller et al. 2009).

Also in line with a “development from” perspective is the growing evidence for neuronal plasticity throughout development. Neuronal plasticity refers to phenomena whereby neuronal characteristics are responsive to external, including social, experiences, resulting in changes such as in neuronal responsiveness, synaptic connectivity, dendritic branching, gene-expression, and gray and white matter volumes (e.g., Draganski et al. 2004; Edelman and Auger 2011; Fields 2010; Haier et al. 1992; Jäncke et al. 2001; Maguire et al. 2000). Thus, while clearly the brain is not infinitely malleable, neural circuitry develops through, and is altered by, experience (Westermann et al. 2007). Accordingly, the social phenomenon of gender – in which behavior and activities are influenced by stereotypes and norms that are variable across time and place – becomes “part of our cerebral biology” (Kaiser et al. 2009, p. 57).

Importantly, a “development from” perspective makes clear the error of conceptualizing variables such as hormonal level, hormonal effects on brain or behavior, or neural function or structure, as pure biological variables. Rather, they are intertwined with the individual’s life-history and current social context, and sex difference research that proceeds without this insight runs the risk of being misleading and/or uninformative. As Moore (2002, p. 65) pointed out in relation to research conducted within the brain organization framework, research strategies that work from a “development to” perspective, and therefore observe only early hormones and later behavioral outcomes, leave “lots of unexplored territory and many possible pathways, perhaps convoluted ones, from the early hormones and end points of interest.” In other words, such strategies neglect to investigate the complex, dynamic process of development itself. Moore’s work, demonstrating the unexpectedly complex effects of early testosterone on sex-differentiated brain stem characteristics and sexual behavior in rats, has provided an increasingly well-known (although long ignored, see Kaplan and Rogers 2003) example of the problematic nature of a “development to” research approach. Mother rats are attracted to odor cues from the higher levels of testosterone in the urine of males and, therefore, lick and groom male pups more than they do female pups.

Remarkably, this differential maternal treatment of males and females contributes to low-level sexually differentiated brain structure and sexual behavior (Moore 1984; Moore et al. 1992). According to the standard brain organization account, these brain and behavioral differences would be attributed solely to the direct action of early testosterone on the brain.

In light of these challenges to the “development to” perspective implicit in the brain organization account, this chapter examines an important and influential hypothesis derived from the brain organization account. This is the claim that sex differences in fetal testosterone, via permanent effects on brain structure, create inherent differences in sex-typed interests that are reflected in male/female differences in toy preferences in childhood. This behavioral difference is among the most substantial observed in childhood, and exceeds those found in cognition and personality (Hines 2010). Four lines of research are repeatedly put forward as evidence for a brain organization account of sex differences in toy preferences. First, it is argued that sex differences in visual interest in a social versus mechanical stimulus exist even in the first few days of life, prior to either the development of gender identity or exposure to significant gender socialization processes. Second, females with the genetic condition of congenital adrenal hyperplasia (CAH), who are exposed to atypically high levels of fetal testosterone during gestation, show more male-typical toy and activity preferences than do non-affected female controls. Third, it is claimed that sex differences in toy preferences similar to those observed in human children are also found in rhesus and vervet monkeys. Fourth, correlations have sometimes been observed between markers of fetal testosterone levels (taken during the critical period) and later gendered play preferences. These four lines of evidence are regularly presented, both in the scientific literature as well as in popular accounts, as showing that the brain organization account of sex differences in toy preferences is beyond reasonable doubt (e.g., Hines 2011; Hoff Sommers 2012; Orenstein 2011; Saad 2012; Wong et al. 2012).

However, the discussion above raises a priori reasons to suppose that such a conclusion may be premature; and, in fact, substantial methodological and conceptual criticisms have been made of each of the lines of evidence marshaled in support of the hypothesis. The following sections briefly summarize findings, and review and expand critiques of these studies’ methods and conclusions. The final section argues, on both scientific and ethical grounds, a need to better take these criticisms into account, and deploy a “development from” perspective in future research.

The Brain Organization (Masculinization) Account of Sex Differences in Toy Preferences

Many toys enable children to role-play adult activities, and some of these activities and their associated toys are more strongly linked with one sex than with the other (e.g., dolls and tea-sets vs. trucks and guns). Although many behavioral differences between the sexes are modest both in children and adults (Hyde 2005),

from 3 years of age there are substantial sex differences in toy preferences. For example, in a typical lab-based observational study, children were offered a collection of female-typical, male-typical, and neutral toys to play with. Girls spent about 60 % of their playing time with female-typical toys (a set of dishes, a Barbie doll with clothing and accessories, a rag doll with accessories and a cosmetics kit), while boys spent only 6 % of their time on those toys. By contrast, the boys spent 70 % of their time with male-typical toys (a car, a fire-truck, a Lego airplane or Lincoln Logs construction toy, a tool set, a helicopter and a gun), compared with only 13 % for girls (Pasterski et al. 2005). Girls and boys spent similar amounts of time playing with the neutral toys (a puzzle, a board game, books, crayons, and a sketchpad). Parents also report sex differences in questionnaires about their children’s sex-typed childhood activities and interests (e.g., Hines et al. 2004).

Why do these sex differences in toy and activity preferences exist? Self-socialization perspectives emphasize the salience and importance of gender in the social world (Bem 1983), and the motivating effect of this on children, who play an active role in their own gender development once they become aware of their gender identity at about 2 years of age (e.g., Arthur et al. 2008; Bigler and Liben 2007; Martin and Halverson 1981). The salience and functional importance of gender is also a component of social learning perspectives on toy preferences, although these emphasize instead the role of others (such as caregivers) in modeling, channeling, and reinforcing stereotype-consistent behavior (e.g., Bussey and Bandura 1999). These accounts therefore anticipate the appearance of sex differences even prior to the development of gender identity.

However, the brain organization account makes the additional proposal that innate brain differences, arising from sex differences in exposure to fT, contribute significantly to gendered toy preferences. Sex differences in prenatal testosterone levels are suggested to provide the “seeds” of later male/female differences in toy preferences, with “nurture” progressively recruited in ways that amplify these initial psychological biases (Alexander and Wilcox 2012; Baron-Cohen 2007; Berenbaum and Resnick 2007). As to what those psychological biases might be, Alexander (2003) suggested that males are born predisposed to be attracted to movement (since this would have advantaged them in developing hunting skills in prehuman and early humans societies), while females are born predisposed to be attracted to reddish-pink colors and rounded forms evocative of infants (since this would have advantaged them in developing infant nurturance skills). Related suggestions are that males might be more drawn to objects that allow for active play (see Alexander and Saenz 2012), or that they have “[i]nnate predispositions for perceptual attributes or motor affordances of objects” that bias them toward objects or activities that allow for propulsive movement (Benenson et al. 2011, p. 263). A second influential proposal, the Systemizing/Empathizing hypothesis, is that higher levels of fT predispose the (typically) male baby toward understanding and building rule-driven, input-function-output systems. By contrast, lower levels of fT predispose (typically) female infants to attend to empathy-related stimuli; namely,

people (Baron-Cohen 2003). As noted earlier, four lines of research are repeatedly put forward as evidence for a brain organization account of sex differences in toy preferences, and these are each now discussed in turn.

The Newborn Study

While a number of studies have looked for sex differences in toy preferences in infants, intended or unintended gender socialization processes, such as caregiver responses and familiarity effects, could potentially underlie any differences observed. To exclude this as a possibility, a much cited study compared neonates' looking time at a live face versus a mobile (Connellan et al. 2000). These stimuli were chosen to reflect interest in biological/social motion versus mechanical motion. Male and female babies both spent approximately half of the total presentation time looking at the face, which was that of the first author. However, males looked longer at the mobile than did females (52 % of presentation time vs. 41 % for females) and females looked longer at the face than at the mobile. These findings have been interpreted both by the study authors and others as evidence for "innate" sex differences in psychological interests.

However, serious concerns have been raised over the considerable methodological flaws of this study (Nash and Grossi 2007). These include the many differences between the stimuli (any of which could have been responsible for the observed differences), and nonstandard procedures for measuring looking time preference (such as serial rather than simultaneous presentation) and, in particular, the scope for experimenter expectancy effects. The first author was both the face stimulus and controlled the movement of the mobile, yet inadequate efforts were made to ensure that the experimenter was blind to the baby's sex. These are serious methodological shortcomings; moreover, the study has never been replicated. Indeed, a recent study of 4–5 month-old infants, that used a number of different face versus object stimuli, found that both girls and boys preferred faces (Escudero et al. 2013). In addition, no evidence is provided that a newborn's visual preference in this experiment anticipates his/her future abilities and interests: It is an assumption that is "essentially unargued for" and "questionable at best." (Levy 2004, p. 322; see also Nash and Grossi 2007). Indeed, it seems to implicitly assume that newborn visual preference is an early indicator of a future biologically pre-specified developmental outcome.

Toy Preferences in Females with CAH

The toy and activity preferences of females with CAH are of considerable interest to researchers, since they provide a group in which high levels of fT exposure are separated from social rearing as a boy. Studies investigating the toy preferences of females with CAH typically use parental and retrospective self-report questionnaires, and lab-based observational studies. Preferences are compared with those of boys and unaffected female relative controls. For example, studies have compared

scores on the Pre-School Activities Inventory (PSAI), which measures interest in toys and activities, and display of characteristics, that are differentially observed in boys and girls (Golombok and Rust 1993). Both questionnaire and observational studies have consistently found that females with CAH show a stronger preference for male-typical toys and activities, and less interest in female-typical ones, compared with unaffected female relative controls (e.g., Berenbaum and Hines 1992; Hines et al. 2004; Nordenström et al. 2002). For example, Pasterski et al. (2005) found that girls with CAH spent only 21 % of time playing with female-typical toys (compared to 61 % for unaffected girls), and 44 % of time with male-typical toys (compared to 13 %).

These findings are often regarded as providing definitive support for a brain organization account of toy preferences. However, these studies do not directly test its predictions. Clearly, the most appropriate way to test such hypotheses would be for researchers to categorize (or create) toys on the basis of the presence or absence of the features thought to be critical: object features such as movement, color, and form (Alexander 2003); affordance for active play (Alexander and Saenz 2012); or stimuli that represent rule-driven, input-function-output systems versus empathy-related stimuli (Baron-Cohen 2003). Instead, stimuli sets are created on the basis of their popularity with males versus females, a strategy criticized decades ago by Bleier (1986, p. 150) for its presumption that culturally defined masculinity is "as objective and innate a human feature as height and eye color." Thus, when researchers observed that an assumedly "male-typical" toy (the Lincoln Log construction toy) was very popular with control girls, it was eliminated from the male-typical set (Pasterski et al. 2005). Clearly, if it had been chosen a priori on the basis of the presence of features thought to be intrinsically appealing to a masculinized brain, this would have instead constituted counter-evidence to the brain organization account. This approach is problematic, because the features supposedly attractive to a masculinized (non-masculinized) brain are neither exclusive to, nor always present in, male-typical (female-typical) toys. Toy vehicles can be moved, but so too can toy vacuum cleaners, prams, and pull-along toys, none of which are particularly associated with boys. Guns and construction toys do not afford movement more than, say, tea-sets. Cosmetics invite systemizing, since they involve the transformation of an input (the "before" state) into an output (the desired "after" state) via a function (the application of cosmetics). In addition, neither cosmetics nor jewelry are necessarily associated with reddish-pink colors, round features, or empathizing. Stuffed animals, by contrast, have some of these features, yet are rarely used as female-typical toys and are sometimes instead categorized as neutral toys.

Furthermore, neutral toys often arguably have attributes that should be differentially attractive to males and females, according to the Empathizing/Systemizing account (Fine 2010). For example, puzzles, board games, and books are frequently used as "neutral" toys. However, puzzles and board games are arguably "systemizing" activities, and are indeed referred to in a questionnaire designed to measure systemizing tendencies in children, the SQ-Child (Auyeung et al. 2006). In addition, books could arguably be categorized as an empathizing toy, at least in cases

where the book presents characters and their thoughts and emotions (either in text or illustration, depending on the age group under study). Similar issues arise when considering the use of the PSAI. Notably, the questionnaire was not developed to test brain organization accounts of play preferences, but rather to assess gender role behavior in pre-school children. It contains numerous items assessing behaviors that are presumably outside the scope of proposed effects of FT on the intrinsic value of object properties: e.g., interest in jewelry and pretty things, pretending to be a female character, avoidance of getting dirty, and dressing up in girlish clothes.

Thus, the current research approach makes it impossible to distinguish a brain “masculinization” explanation of findings, in which particular characteristics of toys are intrinsically more appealing to boys and females with CAH, from the alternative possibility that females with CAH are less attracted to whatever happens to be culturally ascribed to females and/or more attracted by a cultural ascription with males. This is an importantly different proposition, and there are good reasons to take this alternative account seriously. Gender identity in females with CAH is generally unremarkably female, but nonetheless differs modestly to that of female controls, with slightly more male identification and greater expression of dissatisfaction and unhappiness with a female gender identity (e.g., Berenbaum and Bailey 2003; Meyer-Bahlburg et al. 2006). Moreover, Jordan-Young (2010, 2012) has argued that, in their focus on prenatal hormone exposure, researchers have overlooked other variables also affected by the condition that plausibly influence psychosexual development. These include intensive medical and psychiatric intervention arising from atypical or masculinized genitalia, other physical effects of the condition inconsistent with cultural ideals of feminine attractiveness (such as hirsute appearance and short, heavy stature), and the priming of expectations of masculinity in parents, the girls themselves, and others. To date, the possible role of these other factors in the development of masculinized toy preferences has scarcely been investigated. Research in this direction is currently limited to questionnaires or observations of parental attitudes and behaviors regarding sex-typical and atypical play, the findings from which have been inconsistent (Berenbaum and Hines 1992; Pasterski et al. 2005; Wong et al. 2012), and represent only very early first steps in adequately acknowledging the physiological and psychological sequelae of the condition, as well as understanding how labeling, priming, and expectation effects arising from a diagnosis of CAH might, in complex and iterative ways, affect psychosexual development (see Jordan-Young 2012).

Sex Differences in Toy Preferences in Monkeys

Two studies of toy preferences in monkeys are often cited as support for the idea of “inborn” sex differences in predispositions toward different toy types. The first, an observational study of vervet monkeys’ toy play behavior, compared contact time with male-typical toys (a ball and police car), female-typical toys (a toy pan and a doll), and neutral toys (a picture book and a stuffed dog), presented serially to groups of vervets (Alexander and Hines 2002). (As Jordan-Young (2010) has noted,

this procedure meant that any one individual vervet’s choices were dependent on what other vervets were already playing with.) Between-sex contrasts showed greater male interest in the male-typical toys, and greater female interest in the female-typical toys. The sexes showed equal interest in the neutral toys. Within-sex contrasts found only that females had greater percentage contact with female-typical toys than with male-typical toys. A second study with rhesus monkeys compared interaction (using two dependent variables, total frequency and total duration of contact) with wheeled toys versus stuffed toys (Hassett et al. 2008). Between-sex contrasts found that males and females were equally interested in the wheeled toys. Males and females also spent a similar duration of time with the stuffed toys, but females had a greater total frequency of interaction with these toys. Within-sex contrast revealed that males preferred wheeled toys over stuffed toys, while females showed no preference.

As with the studies of females with CAH, interpretation of these two studies is complicated by the non-hypothesis-driven fashion in which toys have sometimes chosen by researchers. In particular, this approach has enabled male-typical, female-typical, and neutral toys to be categorized differently across studies, with the unintended effect of making findings appear more consistent than they actually are (see Jordan-Young 2010). For example, Servin and colleagues (Servin et al. 2003) classified a ball as a “neutral” toy, and it was the most popular toy (when presented with a choice between a car, ball, and doll) among (control) female girls. However, balls were categorized as a male-typical toy in the vervet monkey study. Similarly, a stuffed animal was a neutral toy in the vervet study, but the sole type of feminine toy in the rhesus monkey study. Importantly, male vervet monkeys played more with the stuffed dog (their favorite toy as a group) than with the car – this is in direct contradiction with the main finding of the rhesus monkey study.

An additional issue with the choice of toys for the monkey studies is that such stimuli are unlikely to hold the same meaning to monkeys as they do to human children, and the “affordances” monkeys might perceive in them are more assumed than proven. For example, as Jordan-Young (2010, p. 236) points out, “[h]ow does a vervet know that the purpose of a cooking pot is not to bang it, throw it, or use it to whack another vervet?” Jordan-Young has noted that although that study’s findings were accompanied by a photo of a male vervet rolling the toy car along the ground, and a female vervet cradling the doll, the frequencies of such behaviors in each sex were not reported. Similarly, Hassett and colleagues chose stuffed animals versus wheeled toys to elicit evidence of different activity preferences, but although data were collected on the specific kinds of behaviors directed toward toys, these were not reported. It is therefore unknown whether, for example, stuffed toys tended to be nurtured, bitten, or thrown (indeed, one trial had to be terminated early when a stuffed toy “was torn into multiple pieces”), or whether play with wheeled toys was more active or involved more object movement than play with stuffed animals. A recent study with young children found that play with female-typical toys was as active as play with male-typical ones (Alexander and Saenz 2012). Furthermore, as Ah-King (2009) has noted, since vervet monkeys

are tree-dwelling vegetarians, it is unclear why males in particular should show a predisposition for the development of hunting skills. Rather, the ability to navigate in space would be necessary for survival in both sexes.

One final point of criticism targets the assumption that sex differences in monkeys' toy preferences cannot be attributed to socialization processes (see Fine 2010). Like humans, primate societies have norms regarding sex roles (such as who gets food, cares for infants, etc.), and these norms can differ across, or even within, species (Burton 1977). For example, male involvement in infant rearing can range from absent to highly involved, even within the same species (Itani 1959; Burton 1992). Burton (1992, p. 45) reported extensive and lengthy male care of young in a Gibraltar troop of macaque species, with young females "kept away from infants so that young males may learn their role." She also observed imitation of infant care by the head male, by male subadults only, who then themselves became involved in infant care (Burton 1972). Interestingly, the behavior of male and female monkeys toward infants only starts to diverge at about 2–3 years of age (Mason 2002) and manipulations of fT exposure (both blocking in males, and increased exposure in females) have no effect on subsequent interest in infants (Herman et al. 2003). These findings indicate non-determination of roles by hormones, a significant role for social learning of sex roles, and challenge the assumption that sex differences in monkeys in play with infant-like toys, for example, must reflect "pure biology," absent the influence of socialization.

Associations Between Markers of Fetal Testosterone and Toy Preferences

A fourth category of studies regularly referred to are those that look for correlations between fT exposure and later gendered play preferences in childhood. The advantage of these studies is that they are based on nonclinical samples (although, in the case of populations who are sampled from mothers undergoing amniocentesis, they are not necessarily representative). Various markers of fT have been used (since ethically it is not possible to sample blood from the fetus unless medically indicated): Amniotic testosterone (aT) is sampled from the amniotic fluid during the procedure of amniocentesis; maternal testosterone (mT) is sampled from the mother's blood; and maternal sex hormone-binding globulin (SHBG), which limits T's functional effectiveness by binding with it, has been used as an inverse proxy for levels of unbound, functionally effective T.

To date, four studies have related markers of fT to later toy preferences (recently summarized in Grossi and Fine 2012, see Table 4.1). The first study assessed behavior using the PSAI and used both mT and maternal SHBG levels as proxies for fT exposure (Hines et al. 2002). In girls only, higher levels of mT (but not maternal SHBG) were associated with more masculine scores on the PSAI. The effect size was very small, explaining only two percent of the variance in score, and no other relationships were significant. (The possibility that mothers with higher vs. lower T levels might create different social experiences that influence their

daughters’ gendered preferences does not appear to have been considered.) Subsequently, Knickmeyer et al. (2005) looked for a relationship between aT and sex-typical play in 4 and 5 year old children, as measured by a questionnaire. No relationship with aT was found in either sex, or in both sexes together. Van de Beek and colleagues explored relationships between mT, aT, estradiol, and progesterone levels and observed play behavior in 13-month-old infants (Van de Beek et al. 2009). They found no relationships with aT, mT, or estradiol. Surprisingly, higher levels of amniotic progesterone were associated with a stronger preference for male-typical toys. Finally, in contrast with these mostly negative findings, Auyeung and colleagues, with a larger sample size, found correlations in both sexes, individually as well as pooled, between aT and PSAI score (Auyeung et al. 2009). It is unclear why this study, with a sample approximately one-third of the size of Hines et al. (2002), found a relation with males that was absent in the earlier study (see Jordan-Young 2010), and whether future work will support these positive relations.

A fifth study, an investigation of Baron-Cohen’s (2003) Systemizing/Empathizing hypothesis, looked for the predicted relations between aT and tendency to prefer systemizing activities in children, using a parental-report questionnaire, the SQ-Child (Auyeung et al. 2006). aT was significantly associated with SQ-Child score (which was greater for boys than for girls), both across the whole sample and for boys and girls separately. However, in addition to the subjectivity of parental report as opposed to observed behavior, only a small number of the items appear to reflect “the drive to analyze or construct systems,” with many items instead appearing to tap into a drive for order, routine, or arrangement of objects (Auyeung et al. 2006, p. S124; see Fine 2010; Grossi and Fine 2012).

One critical concern with these studies is that there is currently no satisfactory evidence that either aT or mT is related to actual fT exposure. In their review of this issue, van de Beek et al. suggested aT as the best index of fT exposure, but acknowledged the lack of knowledge regarding the relationship between levels of aT (the main source of which is fetal urine) and levels in the fetal blood (van de Beek et al. 2004). Indeed, one study that measured mT, aT, and fT between 15- and 23-weeks of gestation found no correlations between the three measures (Rodeck et al. 1985). A more recent clinical study did find that fT correlated with mT (Gitau et al. 2005). However, mT levels are not higher in women pregnant with boys than in those pregnant with girls (Hines et al. 2002; Rodeck et al. 1985), which suggests that “maternal serum androgen levels are not a clear reflection of the actual exposure of the fetus to these hormones” (van de Beek et al. 2004, p. 664). That markers of fT may not correlate with actual fT exposure is of considerable concern in terms of interpretation of findings (Fine 2010).

Conclusions and Future Directions

As noted earlier, a brain organization account of sex differences in toy preferences is regularly presented as though it were beyond reasonable doubt. Yet as this chapter has shown, there are significant methodological and conceptual issues,

and empirical uncertainties, surrounding each of the four categories of evidence. There is considerable tension between the brain organization account and the rejection of “development to” models within developmental science, and Jordan-Young (2010) has comprehensively documented the empirical inconsistencies and contradictions of the data supposedly supporting brain organization theory as applied to humans (see also Fine 2010; Grossi and Fine 2012).

Moreover, more generally, the scientific assumptions implicit in “development to” based accounts – that brain circuitry is largely fixed by a genetic blueprint, that there is unidirectional, causal pathway from genes to behavior via hormones and brains, and that evolution has left us with brains and mental processes strongly reminiscent of our Paleolithic ancestors – have been widely rejected following conceptual and empirical upheavals in the relevant scientific fields (see Fine et al. 2013). A “development from” perspective is more consistent with contemporary perspectives that humans have evolved an adaptively plastic brain that is responsive to environmental conditions and experiences, and the modulation of endocrine function by those experiential factors contributes to that plasticity (for relevant reviews, see Brown et al. 2011; Lickliter and Honeycutt 2003; May 2011; van Anders and Watson 2006). Together with evidence of the considerable variation, across time and place, in gender roles (see Wood and Eagly 2013), the need to question implicit assumptions – such as that current, Western categorizations of toys as masculine and feminine correspond precisely with innate predispositions, or that social learning can be overlooked when considering the behavior of nonhuman monkeys – becomes more obvious. The need to question implicit or explicit “development to” assumptions will be no less important as researchers attempt to relate fetal endocrine exposure to later brain states (e.g., Lombardo et al. 2012).

Children’s play worlds are society writ small, and scientific accounts of how and why sex differences in play preferences develop therefore have important political ramifications. Continuing to ignore critiques of the research not only has scientific implications, but also political and ethical ramifications in terms of which groups benefit from what knowledge is produced, as well as from what knowledge is not produced (Haslam and McGarty 2001). Since power hierarchy and inequalities are embedded in gender as a social system, a scientific claim that presents gendered preferences as to some extent “innate” is not politically or socially inert. Brain organization accounts propose that prenatal hormones provide an initial “seed.” This initial biologically based “seed” then recruits experience, as the child seeks out the kinds of toys and activities s/he finds most rewarding (although it is generally acknowledged that this is amplified by gender socialization processes). Thus, Baron-Cohen (Baron-Cohen 2007, p. 169) refers to socialization factors “amplifying” what is innately specified, and argues that “we should not expect the sex ratio in occupations such as math or physics to ever be 50–50 if we leave the workplace to simply reflect the number of applicants of each sex who are drawn to such fields.” Berenbaum and Resnick (2007) describe hormonal influences as furnishing the “seeds of career choices” (p. 147), and “propose that sex-related career choices and outcomes arise through the mediating and moderating effects of socialization on sex-hormone-influenced individual differences in behavioral development.” (p. 148).

Similarly, Alexander and Wilcox (2012, pp. 400–401) refer to hormonally produced “sex-linked dispositions that represent ‘seeds’ of later behavior,” and suggest that sex differences may be smaller in infancy than later in development “when expressed behavior presumably reflects the further influence of experiential factors.” Popular accounts of the social implications of the data often similarly subscribe to the compounding sex-segregation of interests, as “nature” recruits “nurture” (e.g., Hoff Sommers 2012). Importantly, since the “development to” perspective conceives of a unidirectional causal pathway from genes to hormones to brain to behavior, the biological is seen as causally primary in the developmental pathway. This privileging of the biological as somehow more “real” than social contributions is illustrated by the recent comment, by a leading researcher from the brain organization perspective, that research into sex differences in toy preferences “reveals both how humans develop, and how societal pressures act upon children.” (Hines 2013). That is, there is “real” (i.e., biologically based) development that social experiences then merely acts upon.

Brain organization accounts therefore see an original, “essential” difference between the sexes, which is then amplified by experience in a developmental cascade. Such “essentialist” views are associated with increased gender stereotyping, self-stereotyping, stereotype threat, and comfort with the gender status quo (see Fine 2012; see ► Chap. 91, “Sex and Power: Why Sex/Gender Neuroscience Should Motivate Statistical Reform” in this volume). While scientists may prefer to think that political and ethical values lie outside their domain of consideration, as the foregoing discussions indicate, such values are implicitly at work in the research questions that are asked, the rigor of the methodologies chosen, the background assumptions made, the emphasis on certain findings over others, and assessments of the uncertainty that is considered tolerable in order for a particular conclusion to be drawn (Douglas 2008; Haslam and McGarty 2001). Importantly, the future research directions that naturally arise out of the critiques presented here could all potentially produce knowledge that challenge an essentialist account of sex differences in toy preferences. For example, hypothesis-driven selection of toys based on the presence or absence of supposedly critical features (rather than cultural association with males vs. females) could potentially produce data that strongly challenge the brain organization account in a way that the current research approach cannot. It is noteworthy that such studies have never yet been conducted, despite Bleier’s critique of the standard approach nearly 30 years ago (Bleier 1986). Interestingly, the few recent studies that have investigated whether particular features of toys differentially appeal to males and females have not supported brain organization account proposals that females are drawn to pinkish-reddish colors (Jadva et al. 2010) or that males are drawn to toys that afford active play (Alexander and Saenz 2012), although Benenson et al. (2011) found sex differences in imitation of propulsive action in 6–9 month-old infants. Similarly, nonhuman primate research, building on recent findings from the social learning literature that these animals show discrimination in who they learn from (Mondragón-Ceballos et al. 2010; van de Waal et al. 2010), could seek to answer the question posed by Hines and Alexander (2008, p. 479): “if some animals of one sex could be trained to use a particular object, would others of that sex model

them?” Together with comparisons between groups with different sex role norms, again, such data could potentially destabilize the conclusion that human sex differences in toy preferences are “innate” and inevitable. Finally, in contrast with a “development to” perspective, a “development from” perspective allows for the possibility that, as is observed in animal hormonal studies, “an early push in a certain direction can be *either enhanced or entirely eliminated* by subsequent experience, such that development from that point forward would proceed as though the early hormone exposure had never happened.” (Jordan-Young 2010, p. 288, emphasis in original). Greater attention needs to be paid to the complex and dynamic process of development itself when it comes to toy preferences (for discussion, see Fausto-Sterling et al. 2012).

In summary, for both scientific and social reasons, researchers need to incorporate a “development from” perspective that brings a conceptually sophisticated understanding of both development and gender to this politically important and sensitive scientific question.

Cross-References

- ▶ [A Curious Coincidence: Critical Race Theory and Cognitive Neuroscience](#)
- ▶ [Developmental Neuroethics](#)
- ▶ [Feminist Ethics and Neuroethics](#)
- ▶ [Feminist Neuroethics: Introduction](#)
- ▶ [Feminist Philosophy of Science and Neuroethics](#)
- ▶ [Neuroethics and Identity](#)
- ▶ [Neuroethics of Neurodiversity](#)
- ▶ [Sex and Power: Why Sex/Gender Neuroscience Should Motivate Statistical Reform](#)
- ▶ [Toward a Neuroanthropology of Ethics: Introduction](#)

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