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ORIGINAL PAPER

Are There Parental Socialization Effects on the Sex-Typed Behavior of Individuals with Congenital Adrenal Hyperplasia?

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Abstract Influences of prenatal androgen exposure on human sex-typical behavior have been established largely through studies of individuals with congenital adrenal hyperplasia (CAH). However, evidence that addresses the potential confounding influence of parental socialization is limited. Parental socialization and its relationship to sex-typical toy play and spatial ability were investigated in two samples involving 137 individuals with CAH and 107 healthy controls. Females with CAH showed more boy-typical toy play and better targeting performance than control females, but did not differ in mental rotations performance. Males with CAH showed worse mental rotations performance than control males, but did not differ in sex-typical toy play or targeting. Reported parental encouragement of girl-typical toy play correlated with girl-typical toy play in all four groups. Moreover, parents reported encouraging less girl-typical, and more boy-typical, toy play in females with CAH than in control females and this reported encouragement partially mediated the relationship between CAH status and sex-typical toy play. Other evidence suggests that the reported parental encouragement of sex-atypical toy play in girls with CAH may be a response to the girls' preferences for boys' toys. Nevertheless, this encouragement could further increase boy-typical behavior in girls with CAH. In contrast to the results for toy play, we found no differential parental socialization for spatial activities and little evidence linking parental socialization to spatial ability. Overall, evidence suggests that prenatal androgen exposure and parental socialization both contribute to sex-typical toy play.

Keywords Gender development · Gender role · Congenital adrenal hyperplasia · Parental socialization · Sex-typical toy play · Spatial ability

Introduction

Prenatal androgen exposure influences human gender development, including the development of toy and activity preferences and perhaps of some spatial abilities that show sex differences. Much relevant evidence has come from studies of girls with congenital adrenal hyperplasia (CAH), a disorder that causes increased androgen exposure beginning prenatally, especially in affected girls (Pang et al., 1980; Wudy, Dorr, Solleder, Djalali, & Homoki, 1999). Compared with same-sex controls, girls with CAH have been found to be more male-typical in regard to various sex-typical behaviors, particularly toy play (for a review, see Hines, 2010). In addition, females with CAH are sometimes found to show improved spatial abilities and males with CAH to show reduced spatial abilities (Berenbaum, Bryk, & Beltz, 2012; Hampson, Rovet, & Altmann, 1998; Hines et al., 2003). Prenatal androgen exposure appears to contribute to these behavioral changes, but parental encouragement of these behaviors in children with CAH could also play a role, although studies of this possibility have so far been inconclusive.

CAH is a recessive genetic disorder altering synthesis of adrenal steroid hormones. More than 90 % of patients with CAH are deficient in the 21-hydroxylase enzyme (Miller & Morel, 1989) leading to impaired cortisol synthesis and excessive adrenal androgen production. There are two phenotypic expressions

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of the disorder, with the salt-losing expression more severe than the simple-virilizing expression. Girls with CAH are born with genital virilization, the degree of which varies with disease severity (Prader, 1954) and are almost always assigned and reared as females. Boys with CAH are born with normal masculine genitalia and are always assigned and reared as males.

Compared with typically-developing girls, those with CAH show increased preferences for male-typical toys, playmates, and activities (Berenbaum & Hines, 1992; Ehrhardt & Baker, 1974; Nordenstrom, Servin, Bohlin, Larsson, & Wedell, 2002; Pasterski et al., 2005; for a review, see Hines, 2010), increased aggression (Berenbaum & Resnick, 1997; Mathews, Fane, Conway, Brook, & Hines, 2009; Pasterski et al., 2007), reduced interest in infants and parenting (Leveroni & Berenbaum, 1998; Mathews et al., 2009; Money & Ehrhardt, 1973), and increased male-typical sexual orientation (Hines et al., 2004; Meyer-Bahlburg, Dolezal, Baker, & New, 2008; Nordenstrom et al., 2010; Zucker et al., 1996). In addition, although 95 % or more of females with CAH have a female gender identity (Dessens, Slijper, & Drop, 2005), the strength of this female identity may be reduced (Hines, Conway, & Brook, 2004). There is also some evidence of improved targeting ability (Hines et al., 2003), and perhaps other spatial abilities (Berenbaum et al., 2012; Hampson et al., 1998), although results are inconsistent (Hines et al., 2003).

The behavior of boys with CAH generally has been found to be unaltered (Hines, 2004), though there is some evidence of reduced male-typical rough-and-tumble play (Hines & Kaufman, 1994; Pasterski et al., 2011) and reduced spatial performance (Berenbaum et al., 2012; Hampson et al., 1998; Hines et al., 2003). Findings are inconsistent across behaviors, perhaps because males with CAH are subject to inconsistent early androgen elevation due to negative feedback, which may reduce androgen production at some times (Hines, 2004; Mathews et al., 2004).

Several lines of research suggest that prenatal androgen exposure, rather than other consequences of CAH, is responsible for the masculinized play observed in girls with CAH. For example, greater severity of the disorder is associated with more pronounced behavioral masculinization in girls with CAH (Meyer-Bahlburg, Dolezal, Baker, Ehrhardt, & New, 2006; Nordenstrom et al., 2002). Normal variability in maternal testosterone during pregnancy also relates positively to male-typical play in typically-developing female offspring (Hines et al., 2002) and testosterone in amniotic fluid relates positively to male-typical play in typically-developing boys as well as girls (Auyeung et al., 2009), though not in smaller studies using measures of play that do not show large sex differences (Knickmeyer et al., 2005; van de Beek, van Goozen, Buitlaar, & Cohen-Kettenis, 2009). Moreover, two studies of non-human primates (Alexander & Hines, 2002; Hassett, Siebert, & Wallen, 2008) have found sex differences in toy preferences similar to those seen in children, suggesting an inborn contribution to sex-typical toy preferences.

The role of testosterone in sex differences in spatial ability is less clear. Some studies report CAH-related differences in spatial ability, but others do not (for a review, see Hines, 2004). Normal variation in amniotic testosterone has been reported to relate positively to speed of mental rotations, but not accuracy, in a subset of girls who used rotational strategies. Also, similar findings were not apparent in boys in the same study (Grimshaw, Sitarenios, & Finegan, 1995). In addition, amniotic testosterone has been reported to relate to one spatial ability that typically shows a negligible sex difference (disembedding), but not to others in the same study that typically show large sex differences (targeting and mental rotation) (Auyeung et al., 2012). Moreover, females with male co-twins have been found to score higher on mental rotations than females with female co-twins (Cole-Harding, Morstad, & Wilson, 1988), but this type of study is hard to interpret, partly due to difficulty separating any influence of the early hormone environment from that of growing up with a male twin.

In addition to evidence of hormonal influence, increased parental socialization of masculine behavior, perhaps due to awareness of genital virilization at birth, also has been suggested to contribute to male-typical play behavior in girls with CAH (e.g., Fausto-Sterling, 1992; Kessler, 1998; Quadagno, Briscoe, & Quadagno, 1977; Slijper, 1984). Support for this hypothesis is limited, however.

In regard to socialization of typically-developing children, parents provide sex-typical environments, such as room decor and clothing (for a review, see Maccoby, 1998), and also actively socialize them by encouraging gender-appropriate behavior and discouraging gender-inappropriate behavior. Two extensive reviews suggest that differential parental treatment for boys and girls, though largely absent for social behaviors and abilities, is evident for sex-typical toy play (Lytton & Romney, 1991; Maccoby & Jacklin, 1974). For instance, parents encourage girls to play with dolls and discourage them from playing with toy soldiers whereas they encourage boys to play with building blocks and discourage them from playing with dolls (Fagot, 1978; Langlois & Downs, 1980). Moreover, in typically-developing children, the amount of parental reinforcement of sex-typical toy play relates, as predicted, to children's amount of sex-typical toy play (Pasterski et al., 2005).

In regard to parental socialization of children with CAH, one study found no consistent group differences for attitudes and behavior of parents of girls with CAH, parents of girls with progestin-induced genital virilization, and parents of girls with an endocrine abnormality caused by Turner Syndrome but normal-appearing genitalia (Ehrhardt, 1969, p. 15 girls in each group). Also, parents of all three groups reported encouraging feminine behavior in their daughters and being not too concerned about their daughters' behavior. Similar results were found for 17 girls with CAH and sibling controls (Ehrhardt & Baker, 1974). Parents reported that they were not concerned about their daughters' genital virilization and did not think that the virilization caused their daughters' male-typical behavior. Also, parents of girls and boys with and without CAH have not been found to differ significantly in their responses to the question "I encourage my child to act as a boy/girl should" although the girls with CAH showed increased male-typical toy preferences (Berenbaum & Hines, 1992, 26 girls and 11 boys with CAH, and relative controls).

It has also been found that the presence of a parent does not influence the observed toy preferences in girls with CAH (Nordenstrom et al., 2002 on 40 girls with CAH and 40 unaffected girls; Servin, Nordenstrom, Larsson, & Bohlin, 2003 on 26 girls with CAH and 26 unaffected girls), and parents wish their typically-developing girls to be more masculine, but their girls with CAH to be less masculine (Servin et al., 2003). In one observation of parents along with their children as they played, parents did not encourage male-typical toy play in girls with CAH, but instead encouraged girl-typical toy play in these girls more than in unaffected girls (Pasterski et al., 2005).

In summary, evidence to date does not support the hypothesis that parents of girls with CAH encourage them to engage in boy-typical toy play. If anything, parents of girls with CAH appear to encourage them to be more feminine rather than more masculine. However, studies are few in number and are often methodologically limited, for instance, because they used single items to assess parental encouragement or did not measure encouragement of specific behaviors. Also, encouragement of activities other than toy play remains largely unexplored and there is little information relating parental encouragement to the child's behavior. Therefore, the possibility that parental socialization contributes to the masculinized toy interests of girls with CAH cannot be eliminated. The current study assessed parental encouragement of sex-typical toy play, as well as encouragement of spatial activities, in offspring with and without CAH. In addition, it evaluated the relationships between parental encouragement and offspring toy play and spatial ability.

Method

Participants

The study included two samples of individuals with CAH and their unaffected relatives. The adolescent–adult sample included 40 females and 29 males with CAH and 29 female and 30 male unaffected relatives (57 siblings, 2 first cousins), ages 12–45 years, born between 1953 and 1987 ($M = 1979$). All participants were recruited in the United Kingdom (UK). Ages of groups (in years) were as follows: females with CAH ($M = 19.50$, $SD = 7.30$), unaffected females ($M = 19.26$, $SD = 5.95$), males with CAH ($M = 20.27$, $SD = 8.43$), and unaffected males ($M = 18.00$, $SD = 6.81$). All families were European except one that was South Asian. Individuals with CAH were recruited through endocrinologists or via a CAH support group in the UK. Ninety-four percent of the CAH sample had the salt-losing form of CAH and 6 % had the simple virilizing form.

The child sample included 37 females and 31 males with CAH and 27 female and 21 male unaffected relatives (all siblings), ages 3–10 years, born between 1981 and 1997 ($M = 1990$). Twenty-nine children with CAH and 13 unaffected relatives were recruited in the UK and 39 children with CAH and 35 unaffected relatives were recruited in Los Angeles, California. Ages of groups (in years) were as follows: females with CAH ($M = 5.74$, $SD = 2.33$), unaffected females ($M = 6.02$, $SD = 2.14$), males with CAH ($M = 7.18$, $SD = 2.06$), and unaffected males ($M = 7.46$, $SD = 2.45$). Forty-seven percent of the Los Angeles sample was Hispanic, 38 % was White, and 15 % was Black. The UK sample was White, except two families that were of mixed race (Black/White). Individuals with CAH were recruited through endocrinologists or through a CAH support group in the UK. Ninety-eight percent of the CAH sample had the salt-losing form of CAH and 2 % were simple virilizers. Together, the two samples included 77 females with CAH, 60 males with CAH, 56 unaffected female relatives, and 51 unaffected male relatives.

Measures

Parental Encouragement of Boy- and Girl-Typical Toy Play

Scales measuring parental encouragement of boy- and girl-typical toy play were constructed for the current study and were the same for the two samples. The boy-typical toy play scale consisted of three items, assessing encouragement of play with guns, vehicles (cars, trucks, helicopters or other vehicle toys), and construction toys (Legos, tinker toys or other building toys). The girl-typical toy play scale consisted of three items, assessing encouragement of play with dolls (baby dolls, Barbie dolls or other female dolls), grooming toys (make-up, mirrors, and hairbrushes), and kitchen toys (toy dishes, pots and pans or other toys related to food preparation). Parents of adolescents and adults were asked to recall their encouragement of play with each type of toys when their child was 4–10 years old using a 4-point Likert scale (0 = *no encouragement*, 1 = *slight*, 2 = *moderate*, 3 = *strong*). Parents of children were asked to respond to the same questions based on what happened in the present and the past 6 months.

Childhood Toy Play

Measures of childhood toy play differed for the two samples. The adolescent–adult sample used a self-report measure and the child sample used two measures, a parent report and an observation of toy choices in a playroom.

Adolescent–Adult Sample: Preschool Activities Inventory (PSAI). Adolescent–Adult Sample: Preschool Activities Inventory (PSAI). Childhood sex-typical toy play in the adolescent–adult sample was assessed using items from the PSAI (Golombok & Rust, 1993). The PSAI consists of 24 items assessing frequency of play in regard to a variety of toys, games, and activities on a 5-point scale ranging from "never" to "very often." The PSAI was designed to capture both between and within sex differences in behavior.

Higher scores reflect more male-typical behavior and lower scores reflect more female-typical behavior. The measure has been standardized and validated for young children in several countries (Golombok & Rust, 1993). In this study, adolescent and adult participants completed the PSAI retrospectively to describe their own behavior when they were 2–7 years old. We analyzed responses to the seven items involving toy play. These assessed play with four boy-typical toys (tool sets, trains, cars or airplanes, swords or objects used as swords, and guns) and three girl-typical toys (dolls, doll's clothes or doll's carriage, jewelry, and tea sets).

Child Sample: Parent-reported boy-/girl-typical toy play and observed toy play. Sex- typical toy play in the child sample was assessed using parental report on boy- and girl- typical toy play scales as well as via observation of toy choices in a playroom. The parental report scales for children's toy play included the same items as described above for the parental encouragement of boy- and girl-typical toy play scales, but used a 7-point Likert scale ranging from "*never or almost never did*" to "*daily*" and were based on what happened in the present and past 6 months. For the observational measure, each child was observed in a playroom with access to girl-typical toys (dish set, Barbie doll, infant doll, rag doll, and cosmetic set), boy-typical toys (car, fire truck, helicopter, Legos for the UK sample/Lincoln log for the LA sample, tool set, and gun), and neutral toys (puzzle, board game, books, crayons, and sketchpad). The child played alone for 8 min, of which 6 min were coded. The remaining 2 min were used if portions of the initial 6 min could not be scored. The toys were arranged in a circle with no two female-preferred, male-preferred, or neutral toys adjacent. One of six possible arrangements was chosen at random for each child to eliminate possible effects of toy placement. Each child was told to play with the toys however s/he wanted. For coding, the session was divided into 72, 5-s intervals. The measure of play with each toy was the percentage of such intervals during which the child played with each toy. More details about the observation can be found in Pasterski et al. (2005).

Parental Encouragement of Spatial Activities

We adapted the Parental Encouragement of Spatial Manipulation scale and the Parental Encouragement of Miscellaneous Spatial Experience scale from the Early Life Experiences Questionnaire (ELEQ) (Fraser, 1982), a retrospective measure designed to assess the relationship between behavioral outcomes and childhood experiences from ages 2–14 years. We performed reliability analyses, removing items that did not contribute to the scales if any scale had an $\alpha < 0.70$, repeating this process until the scales could not be improved further. The final Parental Encouragement of Spatial Manipulation scale included four items for the adolescent–adult sample and three items for the child sample (see Appendix 1). The final Parental Encouragement of Miscellaneous Spatial Experience scale included seven items for each sample (see Appendix 2).

Parents of adolescents and adults were asked to recall their encouragement of various spatial activities when their child was 4–10 years old using a 4-point Likert scale (0 = *no encouragement*, 1 = *slight*, 2 = *moderate*, 3 = *strong*). Parents of children were asked to respond to the same questions based on what happened in the present and the past 6 months. The Parental Encouragement of Spatial Manipulation scale and Parental Encouragement of Miscellaneous Spatial Experience scale have previously been found to have good test–retest reliability ($r = .81$ and $r = .60$, respectively) and satisfactory cross-respondent (child/mother/father) consistency ($r = .70$ and $r = .40$, respectively). Moreover, both the spatial manipulation and miscellaneous spatial scales showed significant positive correlations to a composite measure of spatial ability involving mental rotation and spatial visualization ($r = .38$ and $r = .15$, respectively), indicating some criterion and discriminant validity (Fraser, 1982).

Spatial Ability

Two aspects of spatial ability, mental rotations and targeting, were assessed for the adolescent–adult sample, but not the child sample. Both aspects show substantial sex differences (Jardine & Martin, 1983; Linn & Petersen, 1985; Voyer, Voyer, & Bryden, 1995; Watson & Kimura, 1991). We previously reported sex by diagnosis differences for this sample in mental rotations and in targeting (Hines et al., 2003). Here, these results are related to reported parental encouragement of spatial manipulation and of miscellaneous spatial experience.

Mental Rotations Mental rotations ability was assessed using two measures, one in three dimensions (3D) and one in two dimensions (2D). The 3D measure was the revised Vandenberg and Kuse (1978) Mental Rotations Test (Peters et al., 1995), a paper-and-pencil test requiring participants to rotate objects mentally in 3D space. For each of 24 items, a target stimulus was presented on the left and participants determined which two of four stimuli to the right were rotated versions of the target. Each item has two correct answers and a point was given if both were provided.

The 2D measure was the Spatial Relations sub-test of the Primary Mental Abilities Test (Thurstone, 1963), a paper-and-pencil test requiring participants to rotate objects mentally in 2D space. For each of 30 items, a target figure was presented on the left and participants determined which of five figures to the right were rotated versions of it. Each item has one to three correct matches and the score was the number correct minus the number incorrect.

Targeting Targeting ability was assessed by two measures—ball throw and dart throw. Both tests required participants to throw a ball or dart overhand at the marked center of a target board. For each task, participants stood 3 m from the target, and the score was the mean distance of 10 throws from the target's center. For both measures, data were transformed by subtracting the mean distance from the maximum possible distance, so that positive values indicate better performance.

Statistical Analyses

Raw data from the adolescent–adult sample and the child sample were combined after transformation to *z*-scores (which show the distance from the sample mean in terms of standard deviations). Initial 2 × 2 × 2 (sex × CAH status × sample) multivariate analyses of variance (MANOVAs) were used to examine for any main or interaction effects involving sample. No such effects were seen. Therefore, data were analyzed using planned *t* test comparisons, collapsed across samples to examine the main hypotheses of interest, including differences between (1) unaffected females and unaffected males; (2) females with and without CAH; and (3) males with and without CAH. Cohen's *d* values are reported for the planned comparisons, with positive effect sizes indicating greater values for males or individuals with CAH. Age was not found to differ across groups in either sample and, therefore, was not included as a covariate in any analysis. Pearson's correlations were used to explore relationships between parental encouragement and behavioral outcomes. Multiple regressions and Sobel tests were conducted on behaviors that parents of different groups reported encouraging differently and which correlated with parental encouragement, to test for possible mediation. We used two-tailed tests for the analyses of parental encouragement and correlations, and one-tailed tests for childhood activities and spatial ability, where specific predictions were made. Note that degrees of freedom varied for different analyses due to missing data or because of unequal variance in the groups being compared. Participants who had some data missing did not differ from those who did not regarding age, sex, or diagnostic group.

Results

Parental Encouragement of Boy-/Girl-typical Toy Play

Figure 1 shows parental encouragement of sex-typical toy play. Reliabilities for the encouragement of boy- and girl-typical toy play scales were 0.59 and 0.77, respectively, for the adolescent–adult sample, and 0.61 and 0.62, respectively, for the child sample. Parents reported giving unaffected males less encouragement of girl-typical toy play, $t(71) = 6.41, p < .001, d = -1.20$, unequal variances, and more encouragement of boy-typical toy play, $t(101) = 4.02$, $p < .001$, $d = 0.79$, than they did unaffected females. Parents also reported giving females with CAH less encouragement of girl-typical toy play, $t(95) = 2.75, p = .007, d = -0.51$, unequal variances, and more encouragement of boy-typical toy play, $t(127) = 2.18, p = .031, d = 0.38$, than they did unaffected females. Parents did not report encouraging males with and without CAH differently for either type of toy play.

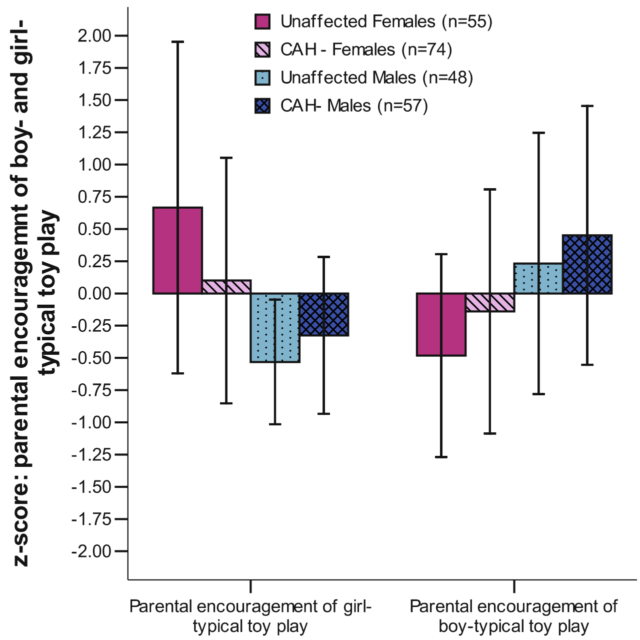

Fig. 1 Parental encouragement of boy- and girl-typical toy play of females and males with and without CAH. The figure shows means of *z*-scores. *Error bars* represent ±1 *SD*. All differences between unaffected males and females, and between females with and without CAH, were significant. No differential parental encouragement was reported for males with and without CAH. Sample sizes are slightly smaller than those reported for the overall sample due to missing data

Childhood Sex-Typical Toy Play

For the adolescent–adult sample, reliabilities for the boy- and girl-typical toy play scales from the PSAI were 0.83 and 0.90, respectively. For the child sample, reliabilities for the parent-reported boy- and girl-typical toy play scales were 0.62 and 0.82, respectively. For observed toy play, toys that matched those in the boy-/girl-typical toy play scales were analyzed. Percentages of play with the car, the fire truck, and the helicopter were averaged to form a vehicle composite, and percentages of play with the rag doll, Barbie Doll, and baby doll were averaged to form a doll composite. Observed boy-typical toy play thus consists of the sum of percentages of play with the vehicle composite, the gun, and the Legos or Lincoln logs, and observed girl-typical toy play consists of the sum of percentages of play with the doll composite, the dish set, and the cosmetic kit. Reliabilities for the observed boy- and girl-typical toy play scales were 0.30 and 0.66, respectively. Observed boy- and girl-typical toy play correlated with parent-reported boy- and girl-typical toy play at 0.44 ($p < .001$) and 0.70 ($p < .001$), respectively.

Raw data from the two samples were combined after transformation into *z*-scores. Because two measures of toy play were available for the child sample, we report two sets of combined data. One combined the *z*-scores of self-reported boy-/girl-typical toy play from the adolescent–adult sample with the *z*-scores of parent-reported boy-/girl-typical toy play from the child sample (*Boy Play-RR* and *Girl Play-RR*). The other combined the *z*-scores of self-reported boy-/girl-typical toy play from the adolescent–adult sample with the *z*-scores of observed boy-/girl-typical toy play from the child sample (*Boy Play-RO* and *Girl Play-RO*).

Figure 2 shows boy- and girl-typical toy play. Compared with unaffected females, unaffected males had less *Girl Play-RR*, $t(91) = 10.70$, $p < .001$, $d = -2.15$, unequal variances, less *Girl Play-RO*, $t(77) = 9.59$, $p < .001$, $d = -1.89$, unequal variances, more *Boy Play-RR*, $t(94) = 9.70$, $p < .001$, $d = 1.98$, and more *Boy Play-RO*, $t(94) = 10.64$, $p < .001$, $d = 2.18$. Compared with unaffected females, females with CAH had less *Girl Play-RR*, $t(118) = 6.55$, $p < .001$, $d = -1.21$, unequal variances, less *Girl Play-RO*, $t(87) = 6.68$, $p < .001$, $d = -1.29$, more *Boy Play-RR*, $t(118) = 4.76$, $p < .001$, $d = 0.84$, unequal variances, and more *Boy Play-RO*, $t(118) = 5.71$, $p < .001$, $d = 1.01$, unequal variances. Males with and without CAH did not differ on any play variables.

Parental Encouragement of Spatial Activities

Table 1 shows parental encouragement of spatial activities. Reliabilities for the Parental Encouragement of Spatial Manipulation scale and the Parental Encouragement of Miscellaneous Spatial Experience scale were 0.70 and 0.82, respectively, for the adolescent–adult sample, and 0.66 and 0.73, respectively, for the child sample. Parents did not report any difference in their encouragement of either spatial manipulation or miscellaneous spatial experience between unaffected males and females, between females with and without CAH, or between males with and without CAH.

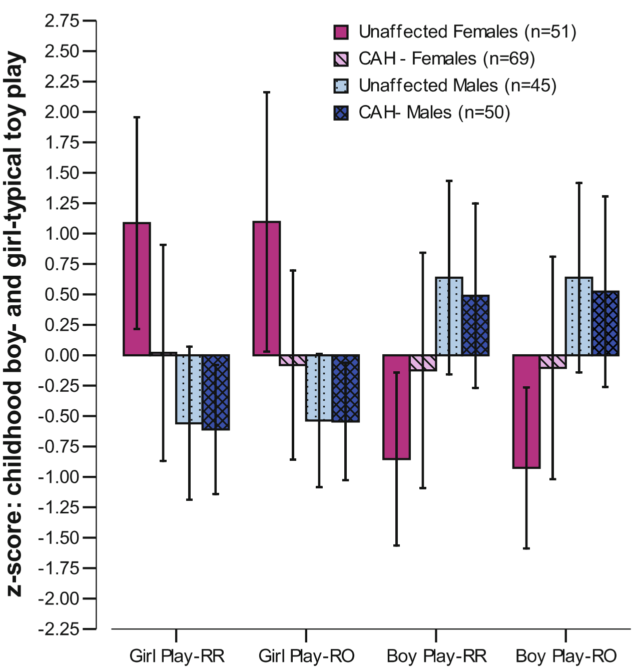

Fig. 2 Childhood boy- and girl-typical toy play of females and males with and without CAH. The figure shows means of *z*-scores. *Error bars* represent ±1 *SD*. *Boy Play-RR and Girl Play-RR* represent the composites of boy- and girl-typical toy play combining adolescent–adult self-report with parent report in the child sample. *Boy Play-RO* and *Girl Play-RO* represent the composites of boy- and girl-typical toy play combining adolescent–adult self-report with observed child data. All differences between unaffected males and females, and between females with and without CAH, were significant. Males with and without CAH did not differ. Sample sizes are slightly smaller than those reported for the overall sample due to missing data

Spatial Ability

Adolescents' and adults' scores from the two mental rotations tasks were combined to form a mental rotations composite and scores from the two targeting tasks were combined to form a targeting composite. These data were also reported in Hines et al. (2003). To be consistent with other analyses in this paper, however, we analyzed the data here using *t* tests instead of ANCOVAs controlling for vocabulary. Results analyzed this way were the same as those reported in Hines et al. (2003). Unaffected males performed better than unaffected females on the mental rotations, $t(48) = 3.5$, $p = .001$, and the targeting, $t(57) = 4.08$, $p < .001$, composites. Compared to unaffected females, females with CAH did not differ on the mental rotations composite but were better on the targeting composite, $t(67) = 2.79$, $p = .004$. Compared with unaffected males, males with CAH did not differ on the targeting composite but were worse on the mental rotations composite, $t(57) = 2.29$, $p = .013$ (for actual data, see Hines et al., 2003).

Relating Parental Encouragement to Sex-Typical Toy Play and Spatial Ability

For each offspring outcome variable, the correlation with parental encouragement of the corresponding variable was evaluated. The *z*-scores were used for childhood toy play because the two samples used different response scales; raw scores were used for the analyses between parental encouragement of spatial activities and offspring spatial ability in the adolescent–adult sample.

Table 2 shows correlations between parental encouragement and offspring sex-typical toy play and spatial abilities. For toy play in unaffected females, there were significant positive correlations for *Girl Play-RR*, $r(49) = .46$, $p = .001$, and *Girl Play-RO*, $r(49) = .32$, $p = .020$. For females with CAH, there were significant positive correlations for *Girl Play-RR*, $r(65) = .57$, $p < .001$, *Girl Play-RO*, $r(65) = .32$, $p = .008$, and *Boy Play-RR*, $r(65) = .24$, $p = .049$. For unaffected males, there were significant positive correlations for *Girl Play-RR*, $r(41) = .61$, $p < .001$, and *Girl Play-RO*, $r(41) = .34$, $p = .026$. For males with CAH, there was a significant positive correlation for *Girl Play-RR*, $r(47) = .30$, $p = .034$, and a significant negative correlation for *Boy Play-RO*, $r(41) = -0.30$, $p = .034$. For males with CAH, parental encouragement of spatial manipulation correlated significantly and positively with both mental rotations, $r(24) = .49$, $p = .011$, and targeting performance, $r(24) = .53$, $p = .006$. Parental encouragement of miscellaneous spatial manipulation also correlated significantly and positively with both mental rotations, $r(24) = .50$, $p = .009$, and targeting performance, $r(24) = .41$, $p = .036$. No

Table 1 Parental encouragement of spatial activities of females and males with and without CAH

Parental encouragement	Females					Males					Sex differences in controls
	Unaffected ($n = 55$)		CAH ($n = 74$)			Unaffected ($n = 47$)		CAH ($n = 57$)			
	M	*SD*	*M*	*SD*	*d*	*M*	*SD*	*M*	*SD*	*d*	*d*
Spatial manipulation	−.21	0.95	−0.06	0.92	0.16	−0.05	0.93	0.30	1.12	0.34	0.17
Miscellaneous spatial	0.03	1.03	−0.05	0.89	−0.08	−0.07	1.03	0.06	1.06	0.12	−0.10

Note. Data are *z*-scores. Sample sizes are slightly smaller than those reported for the overall sample due to missing data

significant correlation was found in any other group for spatial ability.

Predicting Boy- and Girl-Typical Toy Play in Females With and Without CAH

Parental encouragement of boy- and girl-typical toy play was reported to be different for females with and without CAH. Such reported encouragement also correlated with *Girl Play-RR*, *Girl Play-RO*, and *Boy Play-RR* in females with CAH. Therefore, we used hierarchical multiple regressions with CAH status as the predictor in Model 1, and CAH status and parental encouragement of boy- or girl-typical toy play as predictors in Model 2, to evaluate the amount of variance explained by CAH status and parental encouragement for these three sex-typical toy play variables in females. Sobel tests were then conducted using a program written by Dudley and Benuzillo (2004) to test for mediation by parental encouragement in the relationships between CAH status and sex-typical toy play.

The first model for *Girl Play-RR* was significant, $F(1, 116) = 45.26$, $p < .001$, with CAH status explaining 27.4 % of the variance (adjusted $R^2 = .27$, $B = 1.10$, SE $B = 0.16$, $\beta = 0.53$, $p < .001$). The second model was also significant, $F(2, 115) = 50.11$, $p < .001$. The inclusion of parental encouragement of girl-typical toy play explained an additional 18.5 % of the variance (adjusted $R^2 = .45$, R^2 change $= .19$, $B = 0.40$, SE $B = 0.06$, $\beta = 0.44$, $p < .001$). The Sobel test was significant, $z = 2.30$, $p = .021$, and 21 % of the total effect of CAH status and parental encouragement on *Girl Play-RR* was mediated.

The first model for *Girl Play-RO* was significant, $F(1, 116) = 50.57$, $p < .001$, with CAH status explaining 29.8 % of the variance (adjusted $R^2 = .30$, $B = 1.20$, SE $B = 0.17$, $\beta = 0.55$, $p < .001$). The second model was also significant, $F(2, 115) = 35.02$, $p < .001$. The inclusion of parental encouragement of girl-typical toy play explained an additional 7.5 % of the variance (adjusted $R^2 = .37$, R^2 change $= .08$, $B = 0.27$, SE $B = 0.07$, $\beta = 0.28$, $p < .001$), but the Sobel test did not reach the conventional level of significance, $z = 1.77$, $p = .077$.

Table 2 Correlations of parental encouragement with sex-typical toy play and spatial ability in females and males with and without CAH

	Females		Males	
	Unaffected	CAH	Unaffected	CAH
Activity/ability				
Childhood toy play	($n = 51$)	($n = 67$)	($n = 43$)	($n = 49$)
Girl Play-RR	0.46***	0.57***	0.61***	0.30*
Girl Play-RO	0.32*	0.32**	0.34*	0.27
Boy Play-RR	0.14	0.24*	−0.09	−0.03
Boy Play-RO	0.02	0.10	−0.12	−0.30*
Spatial ability	($n = 28$)	($n = 38$)	($n = 27$)	($n = 26$)
Mental rotations (with PE of SM)	0.03	−0.14	−0.12	0.49*
Mental rotations (with PE of MSE)	−0.02	−0.07	−0.08	0.50**
Targeting (with PE of SM)	0.00	−0.21	0.20	0.53**
Targeting (with PE of MSE)	−0.12	0.10	0.20	0.41*

Note. Data are Pearson correlations, two-tailed. *Boy Play-RR* and *Girl Play-RR* represent the composites of boy- and girl-typical toy play combining adolescent–adult self-report with parent-report in the child sample. *Boy Play-RO* and *Girl Play-RO* represent the composites of boy- and girl-typical toy play combining adolescent–adult self-report with observed child data. Sample sizes are slightly smaller than those reported for the overall sample due to missing data. Only the adolescent–adult sample provided data on spatial ability

PE parental encouragement, *SM* spatial manipulation, *MSE* miscellaneous spatial experience

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

The first model for *Boy Play-RR* was significant, $F(1, 116) = 20.75$, $p < .001$, with CAH status explaining 14.4 % of the variance (adjusted $R^2 = .14$, $B = 0.74$, SE $B = 0.16$, $\beta = 0.39$, $p < .001$). The second model was also significant, $F(2, 115) = 14.09$, $p < .001$. The inclusion of parental encouragement of boy-typical toy play explained an additional 4.5 % of the variance (adjusted $R^2 = .18$, R^2 change $= .05$, $B = 0.23$, SE $B = 0.09$, $\beta = 0.22$, $p = .012$). The Sobel test was significant, $z = 2.00$, $p = .045$, and 10.54 % of the total effect of CAH status and parental encouragement on *Boy Play-RR* was mediated.

Discussion

Previous studies found no evidence that parents encourage male-typical behavior in girls with CAH. However, past studies typically did not assess specific aspects of socialization, focused only on toy play, did not relate parental socialization to child behavior, and used small samples. This study looked at parental socialization in a large sample of individuals with and without CAH, looked at toy play and non-toy play variables, and related child behavior to parental socialization.

Parental Socialization and Behavior in Unaffected Males and Females

We found significant sex differences among unaffected controls on the boy- and girl-typical toy play scales and on the spatial ability scales, suggesting that the measures were able to detect sex differences in these areas. The parental encouragement of toy play scales also showed robust sex differences consistent with past findings (Fagot, 1978; Lytton & Romney, 1991; Pasterski et al., 2005). Similarly, despite low reliability for the observed boy-typical toy play scale in the child sample, the different measures of boy- and girl-typical toy play correlated with one another and their composites showed large sex and CAH status differences consistent with prior findings (Berenbaum & Hines, 1992; Nordenstrom et al., 2002; Pasterski et al., 2005; Servin et al., 2003).

Despite detecting robust sex differences in spatial experiences and sex-typical toy play, only sex-typical toy play showed differential socialization by sex, reinforcing prior evidence that boy- and girl-typical toy play is one of the few areas where differential socialization by sex is seen (Lytton & Romney, 1991; Maccoby & Jacklin, 1974).

Parental Socialization and Behavior in Females With and Without CAH

To suggest an effect of parental socialization on the behavioral differences found, a variable should at least: (1) show differential parental encouragement and (2) correlate with parental encouragement of that variable. No differential encouragement of spatial manipulation or of miscellaneous spatial experience was reported for females with and without CAH. Encouragement of spatial activities also did not correlate with mental rotations or targeting ability in females with CAH, despite evidence of criterion and discriminant validity of the parental encouragement scales (Fraser, 1982). These results imply that elevated targeting ability in girls with CAH is not caused by differential parental socialization of spatial manipulation or miscellaneous spatial experience, at least as assessed in this study. Future studies may corroborate this finding by using parental encouragement scales that correlate more strongly with spatial ability.

Encouragement of sex-typical toy play, however, showed a different picture. Boy- and girl-typical toy play were the only variables for which parents reported differential encouragement and for which behavior correlated significantly with this reported encouragement. Parents encouraged more boy-typical toy play and less girl-typical toy play for females with CAH than for unaffected females. These findings contrast with prior reports, using a single item (Berenbaum & Hines, 1992) or interview responses regarding parental attitudes (Ehrhardt, 1969; Ehrhardt & Baker, 1974), of no altered parental socialization for girls with CAH. They also contrast with observational findings (Pasterski et al., 2005) that parents encourage more girl-typical play in females with CAH than in unaffected females.

Also, encouragement of sex-typical toy play correlated with all but one of four variables of sex-typical toy play in females with CAH. Both parental encouragement and CAH status contributed independently to the variance of boy- and girl-typical toy play in females with CAH, and parental encouragement also mediated the relationship of CAH status to *Girl Play-RR* and *Boy Play-RR*. Mediation by parental encouragement was significant when toy play was assessed by self-report in adolescents and adults and parent-report in children, and approached significance when assessed by self-report in adolescents and adults and observation in children. These results suggest that boy-typical toy play in girls with CAH may relate, in part, to parental encouragement, providing some support for the suggestion that parental socialization contributes to behavioral masculinization in these girls (e.g., Fausto-Sterling, 1992; Kessler, 1998; Quadagno et al., 1977; Slijper, 1984).

Why might parents report decreased encouragement of girl-typical toy play and increased encouragement of boy-typical toy play in their daughters with CAH? Our assessment of socialization does not differentiate between encouragement in response to the child's interests versus encouragement that reflects parents' attempts to shape the child's behavior. However, it is likely that the reported encouragement of sex-atypical play is, in part, a parental response to the child's increased interest in masculine play due to prenatal androgen exposure, rather than only initiated by the parent alone. In general, parents respond to their child's behavior (Scarr & McCartney, 1983), encouraging them to play with toys they enjoy. In addition, parents are likely to encourage their child to play with the toys that are available, because there is opportunity to do so. This would explain parents' reported encouragement of cross-sex toy play in their daughters with CAH, despite their wish for these daughters to be less behaviorally masculine (Servin et al., 2003). It also could explain results showing increased parental encouragement of girl-typical toy play in girls with CAH in the structured toy play session (Pasterski et al., 2005), results which might at first appear to be at odds with the current findings. The proximity of boy- and girl-typical toys is artificially determined in structured observations, and perhaps parents take the opportunity to encourage girl-typical toy play in girls with CAH when girls' toys are readily available, consistent with their wish for their daughters to be less masculine (Servin et al., 2003).

However, the mediation by parental socialization between CAH and sex-typical toy play was incomplete, suggesting that much of the alteration in sex-typical toy play in girls with CAH is caused by other factors. This partial mediation is consistent with other evidence that at least some of the change in the toy preferences of girls with CAH is caused by prenatal androgen exposure, including evidence associating androgen with male-typical play in typically-developing children (Auyeung et al., 2009; Hines et al., 2002). Although initiated by the child, parental encouragement of cross-sex play in girls with CAH could contribute to further increases in this behavior. We think that this process begins with altered toy preferences in these girls, however, rather than arising from parents' awareness of genital virilization at birth, as has been previously suggested (Fausto-Sterling, 1992; Kessler, 1998; Quadagno et al., 1977; Slijper, 1984).

Parental Socialization and Behavior in Males With and Without CAH

We found no differential socialization of males with and without CAH. Parents reported the same amount of encouragement of sex-typical toy play and spatial experiences for males with and without CAH. For males with CAH, but not other groups, however, mental rotations and targeting abilities correlated positively with parental encouragement of spatial manipulation and of miscellaneous spatial experiences. Given no differential encouragement for males with and without CAH to engage in these spatial experiences, however, it is unlikely that the reduced mental rotations ability in males with CAH can be attributed to reduced parental encouragement of these experiences.

Limitations

We studied two samples of different ages and somewhat different measures across the two samples. Nevertheless, we saw no effect of sample, suggesting that results from the two samples were similar. This similarity makes it unlikely that the findings from the adolescent–adult sample reflect memory bias associated with retrospective reporting. Similarly, results for the child sample are unlikely to reflect conflating of parental encouragement and behavior caused by both being parent report measures.

A related concern may be the reliability of the parent reports. Behavioral observations might be considered preferable to questionnaires for the study of parental socialization of sex-typical behavior, because observations are thought to be less subject to cognitive biases and to show larger differential treatment of boys and girls (Fagot, 1978; Pasterski et al., 2005). For instance, parents exhibit differential responses to boys and girls playing with sex-typed toys even when they say they do not treat boys and girls differently (Fagot, 1978). However, Fagot's (1978) study asked parents to report attitudes towards gender socialization of boys and girls in general, whereas the behavioral observations involved sex-typed toys. In contrast, we asked parents how they responded to specific behaviors ("I encouraged my child to…") and measured specific behaviors in the child. This match in specificity of parental socialization and child behavior may increase the chance of finding significant correlations (Lytton & Romney, 1991; Turner & Gervai, 1995).

The main argument against parent reports is that parents tend to be insensitive to differential socialization. However, this does not seem to be a problem in our case. Although effect sizes of differential socialization of some behaviors tend to be larger when measured by observations than by interviews or questionnaires, there appears to be no such difference for sex-typed activities such as toy play (Lytton & Romney, 1991). We found expected differential parental socialization of unaffected boys and girls. We also found more differential socialization of girls with and without CAH than previously suggested (Berenbaum & Hines, 1992; Ehrhardt, 1969; Ehrhardt & Baker, 1974), although in a direction different to that observed in the laboratory (Pasterski et al., 2005). These different findings may be explained by the differences between the type of information provided by questionnaires versus observations. First, questionnaires can assess multiple everyday behaviors when no experimenter is present whereas observations, though less subjective, provide only a snapshot of a limited range of behavior with an experimenter present. Second, the stimuli in structured observations, such as toys, are determined by the experimenter whereas parent reports assess what is available in the child's everyday environment, which is influenced by both the child and the parent. Nevertheless, direct information regarding the correlation between parent-reported socialization and actual socialization would be of value.

Conclusion

In summary, this study provides new information regarding the causes of behavioral change in sex-typical toy play and spatial ability in individuals with CAH. Results from two samples were highly consistent. Most importantly, parents reported differential encouragement of sex-typical toy play for females with versus without CAH, and this parental encouragement correlated with sex-typical toy play and partly mediated the relationship between CAH status and sex-typical toy play in females. Parents may encourage more boy-typical toy and less girl-typical toy play in females with CAH because these females prefer boy-typical toy play over girl-typical toy play, and this encouragement may further reinforce females with CAH to engage in more boy-typical toy play and less girl- typical toy play. However, parental encouragement did not seem to contribute to elevated targeting ability in females with CAH or to reduced mental rotations ability in males with CAH. Future studies, using a prospective longitudinal design beginning early in life and socialization measures that tap parents' wishes and expectations, as well as their behavior and that of their child, could provide richer information on how prenatal androgen exposure and postnatal socialization combine to influence sex-typical behavior.

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Appendix 1: Parental Encouragement of Spatial Manipulation Scale

Adolescent–adult sample:

1. Pay attention to the construction of things (e.g., mechanical objects) to see all the parts and how they fit together
2. Learn to make, build, and fix things
3. Look for or "pick out" visual patterns in things (e.g., clouds, stars)
4. Become "handy" with tools

Child sample:

1. Pay attention to the construction of things (e.g., mechanical objects) to see all the parts and how they fit together
2. Learn to make, build, and fix things
3. Become "handy" with tools

Appendix 2: Parental Encouragement of Miscellaneous Spatial Experience Scale

Adolescent–adult sample and child sample:

1. Develop a high degree of coordination
2. Be adventurous in exploring the environment
3. Pay attention to the route being taken when traveling to a new place
4. Play outdoors rather than indoors on nice days
5. Develop a good sense of direction, to become skillful at finding his/her own way around
6. Participate in active sports on a regular basis
7. Be the leader or "guide" when hiking or exploring with friends

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