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Juvenility and the Juvenile Transition

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Overview

Middle childhood is the human equivalent of juvenility, a developmental stage that precedes sexual maturation in social mammals. In many respects, juvenility/middle childhood anticipates adolescence, and several key developmental processes that culminate in adolescence actually begin during juvenility. This chapter reviews the cognitive and behavioral changes that take place in middle childhood from an evolutionary-developmental perspective and frames them in the broader context of human sociality. The chapter also discusses the transition from early to middle childhood (juvenile transition) and its endocrine basis in our species – adrenarche, the onset of androgen production by the adrenal gland. The juvenile transition can be understood as a major "switch point" in the human life cycle, when genetic factors are integrated with current and past environmental influences. This process leads to the onset or intensification of individual and sex differences in many important domains, from aggression and attachment to psychopathology.

Main Text

Middle childhood (conventionally going from about 7 to 11 years) is a phase of human development corresponding to the *juvenile stage* in the life cycle of other primates and social mammals (Bogin *1999*; Pereira and Fairbanks *1993*). From the biological standpoint human juvenility begins with the endocrine events of *adrenarche* (when the adrenal cortex starts producing androgens) and ends with the onset of puberty or *gonadarche* (the activation of the ovaries/testes). Juvenility is marked by slow physical growth, fast-paced learning, and intense social activity, especially in the context of peer relationships; it affords the child a preparatory phase in which to practice social skills and start competing for social status before he/she begins to engage in mating and reproduction. In many respects, juvenility/middle childhood anticipates adolescence, and several key developmental

processes that culminate in adolescence (e.g., changes in aggression patterns, onset of romantic and sexual attraction, improvements in executive functions) actually begin during juvenility. Thus, juvenility should be of great interest to researchers and practitioners concerned with adolescence.
Some years ago we proposed *juvenile transition* as a label for the passage from early to middle childhood (Del Giudice et al. *2009*). As we discuss in more detail below, the juvenile transition appears to be one of the main "switch points" in the human life cycle, when the integration of environmental and genetic factors sets development on alternative pathways – thus contributing to the emergence of both individual and sex differences in behavior.
Juvenility can be defined as a pre-reproductive stage in which the youngster is relatively independent from parents for survival, but still sexually immature. In humans, children become relatively able to feed themselves and protect themselves from predators at about 6–7 years of age. By age 7, gross motor development is complete, walking efficiency is comparable to that of adults, and the brain (the most expensive organ to build and maintain) has virtually stopped growing in weight. At the same time permanent teeth begin to erupt, allowing the child to eat adult-type food instead of the specially prepared foods on which humans universally feed young children (Bogin *1999*). Muscularity begins to increase, and – also thanks to the reduced energetic demands of the brain – the body starts to accumulate fat in preparation for puberty, a process known as *adiposity rebound* (Hochberg *2008;* Kuzawa et al. *2014*)
In the psychological domain, the beginning of juvenility witnesses dramatic increases in self-control, emotional and attentional regulation, and executive functions in general, which collectively go under the label of "the 5- to 7-years shift" (Best et al. *2009*; Sameroff and Haith *1996*). Other important changes include a shift from local to global visual processing, substantial improvements in spatial cognition and wayfinding, and – not least – the emergence of sophisticated mentalizing skills and complex moral reasoning, as children become able to consider multiple points of view and conflicting goals (Jambon and Smetana *2014*; Lagattuta et a. *2009*; Piccardi et al. *2014*; Poirel et al. *2011*) All these changes bring about a rapid increase in self-sufficiency, yet children entering juvenility slow down their growth rate to a minimum and spend an additional 3–5 years in this state before they finally reach adult size and mature sexually.
Whatever the original selective pressures driving the evolution of juvenility, evolutionary scholars agree that this delayed growth phase enables extended learning. In primates, the duration of juvenility correlates with social group size, suggesting that social learning is indeed a crucial function of this life stage. Once equipped with the basic motor and cognitive toolkit, human juveniles engage in active learning and experimentation in all domains: technical skills (e.g., hunting, gathering, manufacturing), caregiving, social roles and strategies, and culturally transmitted abilities in general. The central role of juvenility in social learning is well illustrated by the finding that cross-cultural differences in prosocial behavior are absent in young children, but emerge clearly during middle childhood (House et al. *2013*). On a broader social level, cross-cultural evidence shows that juveniles start "getting noticed" by adults – they begin to be viewed fully as people with their own individuality, personality, and social responsibility (Lancy and Grove *2011*).
In addition to fostering social learning, children's experiences with peers result in real and potentially enduring social outcomes: In middle childhood, status hierarchies and peer networks become more stable; in small-scale social systems the social position acquired in this phase can carry over to adolescence and even adulthood. The first romantic/sexual attractions also appear in middle childhood; as a consequence, children receive important feedback about their desirability as a group member and a mate, and more generally about their competitive abilities in the social world (note that we use "competition" in a broad sense as the pursuit of social acceptance, centrality, and influence; in this sense, social competition often involves cooperative and prosocial behaviors). From the

evolutionary standpoint, the above implies that *sexual selection* (natural selection through mate choice and/or same-sex competition for mates) begins to operate already in middle childhood. As a result, one would expect increased sex differentiation of behavior in middle childhood – and there is abundant evidence that this is the case. Sex differences in aggression, play activities, and language use intensify or peak in middle childhood. For example, there is a peak in fighting and rough-and-tumble play (especially boys), play parenting (usually girls), and sex segregation between groups of boys and girls. Boys also engage in more locomotor and exploratory play, with a wider play range than girls. At the same time, sex differences in aggression become larger, with girls showing substantially less physical aggression and slightly more relational aggression than boys (see Del Giudice *2014*; Del Giudice et al. *2009*). Sex differences in language use also become increasingly apparent: Boys engage in more competitive verbal exchanges while girls start to "specialize" in gossiping (a trend that further increases in adolescence; Locke and Bogin *2006*). Attachment styles also seem to undergo a sex-specific reorganization in middle childhood, with insecure boys shifting toward avoidance and insecure girls toward ambivalence. Sex differences in middle childhood attachment styles may play a role in children's social competition (e.g., by regulating aggressive and cooperative behavior), while also anticipating adult sex differences in romantic attachment styles (see Del Giudice *2015*; Del Giudice and Belsky *2010*).

Taken together, the findings reviewed above suggest the idea that juvenility/middle childhood has two complementary overarching functions, *social integration* and *social competition*. As children become more and more integrated in a social system of roles, norms, and knowledge, they also compete with their peers for vital social resources – status, reputation, allies, and friends. These complementary forces shape the coordinated behavioral changes that characterize the juvenile transition (Del Giudice *2014*).

The dark side of juvenility is early-onset psychopathology (Costello et al. *2003*; Kessler et al. *2005*). The overall prevalence of psychiatric diagnosis peaks at 9–10 years, then declines and rises again around age 14. The middle childhood peak is mainly due to anxiety disorders, ADHD, and conduct disorders. In contrast with mood disorders, several anxiety- and aggression-related syndromes have a typical age-at-onset range that includes (or is even limited to) middle childhood: Specific and social phobias, separation anxiety disorders, oppositional-defiant disorder, conduct disorder, and ADHD. In general, psychopathology in middle childhood involves aggression, impulsivity, and anxiety (including attachment-related anxiety); this is consistent with a phase of activation/reorganization of the motivational systems that mediate social competition and attachment, as hypothesized on the basis of evolutionary theory.

In the course of human evolution, the developmental sequence leading to adulthood has become organized in a number of recognizable stages – infancy, childhood, juvenility, and adolescence. The segmentation of development in distinct stages promotes efficient functional specialization: Young children spend most of their resources on body/brain growth, language learning, and basic cognitive and motor development; juveniles redirect their time and energy away from physical growth and toward skill learning, social learning, and social competition; and adolescents become sexually mature and capable of reproducing, form sexual and romantic relationships, and begin to compete at the adult level for social and material resources. Transitions between stages require a mechanism able to orchestrate physical and psychological changes in a coordinated fashion. The ideal candidates are hormones, messenger molecules that reach everywhere in the body and brain, can directly regulate genetic expression, and respond to the physical and social environment through top-down regulation. Hormonal changes are notoriously involved in the transition to adolescence; it is less widely known that the transition to juvenility has its own hormonal substrate – adrenarche.

Adrenarche (see Auchus and Rainey *2004*; Bernstein et al. *2012*; Hochberg *2008*) is an endocrine process which, to date, has been only described in humans, chimpanzees and (to some extent) gorillas – three apes characterized by unusually long juvenile stages. At about 6–8 years, with little difference between the sexes but substantial individual variation in timing, the cortex of the adrenal glands begins to secrete increasing quantities of androgens, mainly dehydroepiandrosterone (DHEA) and dehydroepiandrosterone sulfate (DHEAS). The sequence of physiological events leading to the initiation of adrenarche remains largely unknown, and it has been suggested that adrenarche may not be triggered by any specific hormonal event, rather resulting from a gradual maturational process that begins in early childhood: DHEAS concentrations progressively increase starting from age 3, in concert with gradual changes in the activity of key steroidogenic enzymes. For instance, as children grow up, the level of the enzyme 3β-hydroxysteroid dehydrogenase (3β-HSD) in the adrenal gland decreases, contributing to increased production of DHEA and DHEAS during adrenarche.

The consequences of adrenarche for bodily development are decidedly minor: They include the initial appearance of pubic and axillary hair, increased oiliness of the skin and hair, changes in body odor, subtle voice changes, and (possibly) a small, temporary acceleration of skeletal growth. In contrast, adrenal androgens can have multiple effects on brain functioning and maturation. DHEA and DHEAS modulate the action of GABA, the main inhibitory neurotransmitter; moreover, the action of DHEAS at sex-steroid receptors may reduce fear and anxiety in social interactions and improve memory by modulating neural activity in the amygdala and the hippocampus. DHEAS may also increase neural plasticity thanks to its role as a synaptic modulator, and may play an important role in shifting the allocation of the body's energetic resources away from brain development and toward the accumulation of muscle and fat in preparation for puberty (see Campbell *2006*, *2011*). In addition to their direct actions, both DHEA and DHEAS can be converted to testosterone and/or estrogen in a number of organs – including the brain. This indirect action of adrenal androgens may account for much of their behavioral effects in middle childhood, and links them to the dramatic intensification of sex differences observed during this developmental stage. In juveniles, adrenal steroids can produce behavioral effects in specific domains regulated by "adult" sex hormones (testosterone and estrogen) while having minimal effects on physical maturation, thus shifting development on sexually differentiated pathways even before full reproductive maturity.

Thanks to the mechanism of adrenarche, the passage from early childhood to juvenility has the quality of a discrete psychobiological event. Our proposed label of a "juvenile transition" was meant to emphasize the shift in developmental function and the accompanying endocrine and neurobiological changes (see also Campbell *2006*, *2011,* for a compatible evolutionary account of adrenarche). In recent years, developmental research has converged on the idea that adrenarche is a sensitive period in development, that is, a time when the organism is maximally susceptible to long-lasting environmental influences (Byrne et al. *2017*). From an evolutionary-developmental perspective, we argued that it is more accurate to regard adrenarche and the juvenile transition as a *developmental switch point*, a specific event in the life cycle when genetic and environmental information is integrated by the organism, thus enabling adaptive plasticity in the shaping of the organism's developmental trajectory (Del Giudice *2014*; Del Giudice et al. *2009*; see West-Eberhard *2003*). Whereas a sensitive period is defined by increased sensitivity to environmental influences, a switch point may trigger or amplify the expression of both environmental and genetic effects at the same time. On the one hand, adrenal androgens can activate sexually differentiated brain structures and contribute to the observed intensification of psychological sex differences. On the other hand, the awakening of sex hormones pathways can reveal individual variation at the genetic level – thus affecting traits such as dominance-seeking, aggression, attachment anxiety, and so on. The bidirectional coupling between sex hormones and the stress system strongly suggests the possibility

that adrenarche is affected by earlier social experiences, and that the action of adrenal androgens is modulated by the effects of early stress. Little is presently known about these processes; however, research has shown that stressful interactions with parents during childhood can anticipate adrenarche in both sexes, and levels of adrenal androgens have been found to correlate with a range of psychopathological symptoms in middle childhood (Byrne et al. *2017*; Ellis and Essex *2007*).

In this perspective, the juvenile transition is only one of the main switch points in the human life history. Other switch points occur during fetal development, puberty, and possibly menopause (Del Giudice and Belsky *2011;* Ellis *2013*). All these events involve the activity of specific hormones, and may thus evoke coordinated responses in the whole organism; in turn, hormonal mechanisms are finely attuned to the information coming from the environment, allowing for adaptive plasticity in physiology and behavior. In this life-history approach, developmental trajectories are not fixed in early life but (at least in some individuals) remain potentially open to revision in the face of social feedback and changing environmental conditions.

Whereas the emergence/intensification of sex differences in middle childhood is well established, less is known about role of the juvenile transition in the development of *individual* differences. Some fascinating evidence in this regard comes from the study of aggressive and antisocial behaviors. A common assumption in the past decades has been that changes in these behaviors (both increases and decreases) tend to happen during adolescence, as exemplified by labels such as "adolescent-limited" or "childhood-limited" that are commonly used to describe individual trajectories. However, empirical studies have revealed that the largest shifts in antisocial behavior take place during middle childhood rather than adolescence; middle childhood is also when aggression levels are most unstable and show the strongest discontinuities in time (Del Giudice et al. *2009*; Sentse et al. *2016*).

The developmental changes observed in the juvenile stage are likely due to a complex interplay of genetic and environmental factors. Longitudinal twin studies support the hypothesis that adrenarche activates previously unexpressed genetic variation: a substantial proportion of the genetic variance contributing to individual differences in middle childhood – in traits as different as language skills, prosociality, and aggression – appears to consist of new genetic factors that were not present in early childhood (Hayiou-Thomas et al. *2012;* Knafo and Plomin *2006*; van Beijsterveldt et al. *2003*). As for the activational effects of adrenarche, we recently found preliminary support for the hypothesis that individual and sex differences in attachment in middle childhood reflect differences in fetal exposure to sex hormones (Del Giudice and Angeleri *2016*).

Conclusion

Juvenility is being increasingly recognized as a critical stage of psychological development. Researchers are becoming more aware of the importance of adrenarche and have begun to investigate the developmental role of adrenal androgens. However, many gaps in knowledge remain, and future research will need to address several key questions. First, much is still unknown about the mechanisms of action of adrenal androgens and their interaction with prenatal and perinatal hormones. In addition, most of the extant evidence linking adrenal androgens with behavior is still correlational, and the causal direction of hormone-behavior relationships will need to be established more firmly. Another knowledge gap concerns variation in the timing of adrenarche: While there is abundant information on the geographic and ethnic variation in puberty timing, little is known about comparable variation in the onset and course of adrenarche (e.g., Mouritsen et al. *2013*). Such information will be crucial to interpret cross-cultural studies of juvenility and to properly aggregate data from different countries and populations. More generally, further research is needed to assess the contribution of the juvenile transition to the development of individual differences, especially in

domains other than aggression and attachment; it will also be extremely important to understand how the motivational and cognitive changes of juvenility intersect at the individual level, for example, how changes in aggression correlate with those in executive functions, verbal behavior, and so on. Finally, building an integrated model of human development will require a deeper understanding of the connections between juvenility and later development, including the functional correlations between adrenarche and gonadarche and the role of social feedback in shaping children's developmental trajectories through juvenility and adolescence.

Cross-References

Adrenarche
Evolutionary Perspectives on Adolescence

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