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(Article begins on next page)

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Juvenility and the Juvenile Transition

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Middle childhood (conventionally going from about 7–11 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 many 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. The passage from early to middle childhood has been recently labeled as *juvenile transition* (Del Giudice et al. 2009). In an evolutionary-developmental perspective, 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). 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). All these changes indicate 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 theorists agree that one of the key current functions of this delayed growth phase is *learning*. 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), parenting, social roles and strategies, and culturally transmitted abilities in general. In primates, the duration of juvenility correlates with social group size, suggesting that social learning is indeed a crucial function of this life stage.

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) operates 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. 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). Recently, it has been proposed that attachment styles 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 would 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. For a brief overview of this hypothesis and of the debate surrounding it, see Del Giudice and Belsky (2010) and the accompanying commentaries.

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 mediating 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 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 able to reproduce, 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 much less known that the transition to juvenility has its own hormonal substrate – adrenarche.

Adrenarche (see Auchus and Rainey 2004) is an endocrine process which, to date, has been only described in humans, chimpanzees and (possibly) 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 increase in adrenal androgens is not accompanied by increased activity of the hypothalamic-pituitary-gonadal axis, confirming that adrenarche and gonadarche are independent maturational events controlled by different mechanisms. This is especially apparent in children with atypical development, where the two processes can dissociate and appear independently of one another.

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 (see Campbell 2006). In addition to their direct actions, both DHEA and DHEAS can be converted to testosterone and/or estrogen in several 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. Del Giudice and colleagues (2009) proposed the label *juvenile transition* to emphasize the shift in developmental function and the accompanying endocrine and neurobiological changes (see also Campbell 2006, for a compatible evolutionary account of adrenarche). They further theorized that the juvenile transition works 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. 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 high levels of adrenal androgens have been described in children with conduct and oppositional-defiant disorders.

In an evolutionary-developmental perspective, the juvenile transition is only one of the main switch points in the human life history. Other switch points include fetal development, puberty, and menopause; another possible switch point is the birth of one's first child. These events all 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 aggression. In the past decades, it was assumed that individual differences in aggression were established early in infancy and remained stable through adulthood, with the exception of a subgroup of children (the "late starters") who became significantly more aggressive during adolescence. However, more recent studies have revealed that unstable aggression trajectories are fairly common, and – most importantly – that major shifts in aggressive behavior take place during middle childhood. In this developmental stage, many children become significantly more or less aggressive (relative to their peers) than they were at earlier ages, with the strongest discontinuities observed between age 7 and 9. Longitudinal studies that include juvenility usually find lower stability in individual differences compared with studies of younger or older age groups. The developmental instability observed in the juvenile stage is 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 appears to consist of new genetic factors that were not present in early childhood.

Juvenility is being increasingly recognized as a critical stage of psychological development. Recently, researchers have become 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, almost nothing is known about comparable variation in the onset and course of adrenarche. Such information will be crucial to interpret cross-cultural studies of juvenility and to properly aggregate the data coming from different nations 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

► Evolutionary Perspectives on Adolescence

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