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Selective hormonal depression of childhood creativity at puberty

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Abstract: Few boys and still fever girls move into adulthood without considerable loss of childhood creativity. Unfortunately, it has neither been possible to develop educational tools to fight the pubertal regression nor to enhance creativity in general. The present work inquired into this problem from a new angle. Creativity was defined in terms of brain functioning. A search was then initiated for causes, effects, and mechanisms behind neural plasticity to test the assumption, that children loosing prepubertal neural plasticity will not show exceptional adult creativity. The General Trait Covariance - Androgen/Estrogen (GTC) model was used to link individual variations in gonadal sex hormones to neural plasticity and creativity. The model combines genetic, hormononal, and experiential factors, identifies cause(s), mechanisms, effects, and emphasizes effects of fetal and pubertal hormones as they coordinate body with brain development and neural plasticity. In particular brain estradiol, whether from plasma or derived by aromatization, was ascribed an important role in the loss of neural plasticity. The GTC model was used to determine which children run a particualr risk of loosing childhood creativity.

Introduction

Exceptional creativity is very rare indeed, as measured by agreed upon extraordinary performance. Less than five percent of all scientists contribute more than fifty percent of the total scientific output (Walberg, Strykowski, Rouai, & Hung (1984), and the number of, say, eminent mathematicians and music composers is indeed small, compared to the potential number.

Why is exceptional adult creativity so rare? One answer could be that there are few creative children to recruit from, but this seems not to be true. Aside from the difficulty of defining creativity in children, most parents and teachers agree that many children demonstrate promising creative traits before puberty, including a high degree of playfulness. Most children easily combine recently learned elements in new, surprising, and often useful ways. Not a few children paint or play music in ways interpreted as creative by professionals. Wehmeyer (1983) estimated, for example, that more than half of the virtuoso musicians in the late 18th century were younger than 14 years. Scott and Moffett (1977) and Bamberger (1982) noted that surprisingly few talents keep their childhood promises in adulthood. The prodigies, the one-in-a-million children that show early extraordinary talents and fullfil all promises in adulthood are not likely to answer the question of why most other children loose their creativity. The question to be addressed here is instead: What is missing in the development of children who loose creativity as they grow up? Why do girls suffer more than boys in this respect. This is puzzling, because there is no sex-related differences in creativity before puberty?

creativity to ordinary performance in adulthood on the basis of a genetic predisposition model insensitive to ontogenetic changes. On the other side, there is a clear tendency for exceptional creativity to run in families (Galton 1869), so lack of genes for creativity might be a factor, nevertheless. Presently all details in the genetic transmission of creativity are missing.

Another argument is that social, educational, or cultural factors depress childhood creativity (e.g. Montessori 1912; Read 1961), but there is solid evidence neither for a particular nor for a generalized effect of training or instruction on creativity (Gaines 1983). Many exceptionally creative children display their talent quite unexpectantly and apparently independently of societal factors, and there are many examples of creative children trying to perform in sharp opposition to parental attitudes and to teachers' intentions. Indeed, the history of science is full of sad stories of creative geniuses, who as children had to fight the traditional wisdom of conservative educational and cultural institutions before recognition. The school system is sometimes accused of being counter-productive for the development of creativity. It is a fact, that most children become less creative during later school years, but there is little evidence to prove that the school is actually responsible for this. Discrimination or repression is sometimes called in to explain that girl's creativity suffers in particular, and the concept of "Learned helplessness" was once in vogue. It may be correct that creative girls are discriminated against (as probably also are some creative boys), but there is little well-controlled evidence to prove the infered causal relationship. Finally, social learning theory (of

It seems fair to conclude, that neither genetic theory nor social learning theory offer testable solutions to the problem of why the initial promises of creativity in many children are never fullfilled in adulthood. Apparently something goes wrong in the development of creativity around puberty that traditional genetic and social teories miss. Even the nature-nurture interaction model is not of much help. Both genetic and environmental variables, and the nature of their interaction are typically formulated in too general terms to be of much scientific value (Nyborg 1987; 1990a; b). It is this vagueness, combined with a lack of interest in causal mechanisms, derivable only from studies of individuals (Nyborg 1977; Nyborg & Sommerlund 1992), and the basically statistically oriented focus on the interaction process that make traditional approaches unfit for anything but as a starting point for investigation.

Neural plasticity.

There are good reasons to suspect that neural plasticity may the limiting factor in the development of creativity, even if the evidence is indirect. The hypothesis is based on the obvious fact that creativity must be brain based. Even slight brain damage can seriously disrupt creativity, and minor developmental brain disturbances often show up in reduced creativity. More importantly, a closer look at developmental time-tables provides suggestions about a temporal relationship between neural plasticity and creativity.

One way to see this is to concentrate on the role of hormones. A growing body of animal and demonstrated that thus treated rats encounter difficulties in adult visuo-spatial learning in a 8 arm radial maze. Learning disabled rats further showed reduced neural Long Term Potentiation (LTP) responses as compared to controls, suggesting that early brain development associates to reduced neural plasticity in adulthood. Reduction in LTP scores correlated with reduced learning scores. There is human evidence to suggest that both very low and very high levels of gonadal hormone in childhood may block later neural processing of visuo-spatial information. In one study Nielsen, Nyborg & Dahl (1977) confirmed previous findings of severe visuo-spatial developmental deficits in girls with Turner's syndrome, which is associated with abnormally low plasma estradiol (E_2 - a potent estrogen). A re-analysis of the data (Nyborg & Nielsen 1981) indicated, that it was the untreated girls with abnormally low E_2 and the long-term E_2 treated girls (on average 8 years) that encountered difficulties in visuo-spatial tasks. The short-term treated girls (average 1.1 year) performed on par with their sisters. In analogy with the results of the studies by Nottebohm (1989), this suggests that moderate levels of gonadal hormones are required for optimum performance in various areas, whereas lower or higher concentrations exert an inhibitive function. To experimentally test these hypotheses Nyborg, Nielsen, Næerå & Kastrup (1992) treated young Turner girls with various combinations of growth hormone, E_2, and androgen, and were able to confirm that one year low-dose E_2 treatment sufficed to bring Turner girls into the control girl visuo-spatial scoring range. Turner girls receiving androgen for two years before the one year E_2 treatment actually performed like superior control boys after treatment.

a necessary condition for the expression of exceptionally high creativity. It has been suggested elsewhere that, what makes exceptionally creative individuals stand out from high IQ people in general is a particular constellation of personality traits, depending in part on the area of excellence (Nyborg 1991).

Gonadal hormones also monitor the tempo of bodily maturation, and affect the unfolding of personality traits. In other words, gonadal hormones are capable of harmonizing the development of body, brain, intelligence, and personality. This central role of gonadal hormones for development was used to explain a relationship between early - late maturation and different kinds of exceptional creativity in Roe's (1970) study of sixty-four eminent scientists via neural plasticity. We know that high pubertal plasma gonadal hormone concentrations cause early closure of the growth zones in the long bones, and that they probably also reduce neural plasticity. Models based on these hypotheses have been in existence for some years. A recent version is used here in an attempt to determine which children are most likely to experience a regression in creativity at puberty, and which are likely to remain creative in adulthood.

The General Trait Covariance - Androgen/Estrogen (GTC - A / E) model

The General Trait Covariance - Androgen / Estrogen (GTC - A / E) model (Nyborg 1979; 1981; 1983; 1984; Nyborg & Nielsen, 1981), is based on the hypothesis, that moderate plasma sex hormone concentrations are beneficial for maximum expression

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Insert figure 1 about here

The GTC - A / E model strives to explain 1) the previously reported fairly high level of creativity in many prepubertal children, 2) the absence of a sex-related difference in creativity in this age range, and 3) the pubertal regression in creativity that strikes most children (and in particular girls), in terms of genes, hormone levels, and experience.

Children are characterized by low to moderate plasma hormone concentrations throughout early childhood (e.g. Nyborg 1993b). This developmental phase is tentatively considered analogous to Nottebohm's (1989) neural plasticity period with high capacity for combining newly learned elements in unusual ways. The moderate hormone concentrations could thus explain the neural basis for optimum childhood expression of a familial disposition for creativity. Toran-Allerand (1984) has demonstrated that absence of E_2 has negative effects on brain growth, whereas increasing doses significantly enhance the size and number of neurons as well as dendritic sprouting. E_2 in moderate doses thus promote synapto-genesis, believed to be essential for creative potentials.

Boys and girls secrete approximately similar amount of gonadal hormones during childhood. This could explain the absence of a sex-related difference in traits, including overshoot the optimum E_2 brain levels by a wide margin, due to a considerable pubertal surge in E_2. This results in early maturation, reduction of neural plasticity, and inhibition of creativity. This post-pubertal phase would correspond to Nottebohm's (1989) stereotypic song period with no new creative learning in the sexually and neurally fully matured male Canary. It would also correspond to the conditions of the visuo-spatially deficient rats with artificially forced brain maturation in the study by Pavlides, Westlind-Danielsson, Nyborg, & McEwen (1991), and the long-term E_2 treated Turner girls. The following general rules can be derived. High early plasma gonadal hormone concentrations enforce body and brain maturation, reduce neural plasticity, and leads to regression in creativity, irrespective of sex. Low early plasma sex hormone concentrations result in delayed maturation, keeps neural plasticity intact, and promote the expression of creativity, irrespective of sex.

It is possible to use the GTC model also for individualized within-sex predictions about the most likely development of creativity based on dose-response considerations and on hormotyping of peri-pubertal children. Hormotyping refers to a rough classification of boys and girls in accordance with the balance among their plasma concentrations of t and E_2. For the sake of clarity in presentation an inverse relationship between t and E_2 concentrations are assumed, but this most likely is an oversimplification (Nyborg 1983; 1993a). Peri-pubertal girls can be classified as hormotype E5 (early and high E_2, early maturation, and full sexual differentiation), as hormotype E1 (late and low E_2, late maturation, and moderate to low sexual differentiation), or as something in between

An S-shaped multiplicative model for the development of creativity

So far it has been argued that high peri-pubertal levels of gonadal hormones counter neural plasticity, the full expression of familial dispositions of abilities and, by implication, creativity. However, high abilities may only be a necessary, but certainly not a sufficient condition of the expression of exceptional creativity. It appears that the absence of particular personality traits is also counterproductive for the unfolding of creativity. Unfortunately, the hormotypes displaying reduced expression of abilities also tend to display personality traits that may prove counterproductive for creativity. This double burden may explain the rarity of exceptionnally creative individuals.

To understand this, the GTC model comes in conveniently, because it is designed specifically to account for covariant body, brain, intellectual, and personality development. Several studies of eminently creative male scientists (reviewed in Nyborg 1993) indicate that they tend to mature mature late, to display some feminine traits in between their male personality traits, to be introverted and to pay little attention to social aspects of interpersonal behavior, to get relatively few children, and to score high on intelligence tests. This constellation of traits in the generalized highly creative male scientist stands in most respect in dire opposition to the trait pattern of most male hormotypes but hormotype A2. Hormotype A3 and A4 boys thus mature either on time or early, display few if any feminine personality traits, tend to be extraverted and sociable, to get the average number of children or more, to behave physically aggressive, and to hormotype E2 girls may run into a problem with the development of creativity. To the extent that exceptional creativity requires high performance score, E2 girls are not likely to display creativity in that particular area, say, mathematics or experimental physics. It is in this perspective interesting to note that when females excell, it is quite often in areas requiring high verbal abilities, such as in creative writing.

To summarize, within-sex hormotyping can be used predictively to tell which boys and girls are most likely to suffer from a pubertal regression of exceptional childhood creativity. To the extent that creativity in particular areas is the exponential product of certain ability and personality traits, some hormotypes are less likely to remain creative after the pubertal surge in gonadal hormones. The absence of just one ability or personality factors equals zero creativity, and all children with hormotypes different from A2 and E2 most likely fails to fulfill this strong requirement. Phrased more positively, exceptionally creative hormotype A2 and E2 children are quite likely to remain creative also in adulthood.

Discussion

The present study struggled to answer the question of why many boys and girls show early signs of creativity in childhood, but then tend to loose this valuable gift at puberty, and girls more than boys? The traditional answers were found to be lacking in several respects, so it was suggested that the study of neural plasticity and its dependency on gonadal hormones might provide more rewarding answers. There is evidence that brain E_2 reduces neural plasticity and thereby the expression of creativity in both sexes. The fact that the E2 surge is larger in girls than in boys was used to explain the larger pubertal regression in creativity in girls than in boys.

Studies of children's musical abilities may illustrate the point. Hassler, Birbaumer & Feil (1985) studies 120 9-14 year old children with respect to ability to compose and improvise, and observed significant correlations to spatial ability tests. Acknowledging, that many gifted children actually loose their musical talent at puberty (Bamberger 1982; Revesz 1946; Scott & Moffett 1977), they expected more girls than boys to regress in talent at puberty because of the spatial ability - musicality relationship. Re-testing 36 most gifted boys and girls, Hassler et al. (1985) found that 16 boys but 13 girls were willing to be tested for compository talent just one year later, and only 1 boy scored "excellent" against 4 the year before. A series of follow-up and new studies (Hassler 1992) of composers and instrumentalists included measurements of t in saliva. Hassler found an optimum range of t concentrations for the expression of creative musical behavior. Creative male composers had significantly lower t than male instrumentalists, and female composers had significantly higher levels of t than female instrumentalists. In the 8-year longitudinal study there was a dramatic decrease in the quality of creative musical behavior in both sexes, but "surviving" male and female musicians both scored high on test for androgyny. It appears that all these observation are well in line with what could be expected of hormotype A2 male and hormotype E2 female predictions of the GTC model. The GTC model may thus be used to point out boys and girls at particular differences (Nyborg 1977; 1987; Nyborg & Sommerlund 1992). One advantage of the GTC model is, that it allows a precise focus on children at particular risk of loosing creativity or, if one pleases, on children less likely to regress, based on single characteristics or on a combination of traits. The causal basis for hormone - brain development - ability - personality relationships have been discussed extensively in several other places (Nyborg 1983; 1984; 1990; 1993a; b) and will not be elaborated further here. Suffice it to mention that future studies of the developent of creative children should perhaps attempt to collect covariate measures of neural plasticity, in addition to sophisticated measurement of several hormonal parameters, preferably in longitudinal or mixed designs, in which a possible tendency to familiar transmission of creativity is also acknowledged. The show has just begun.

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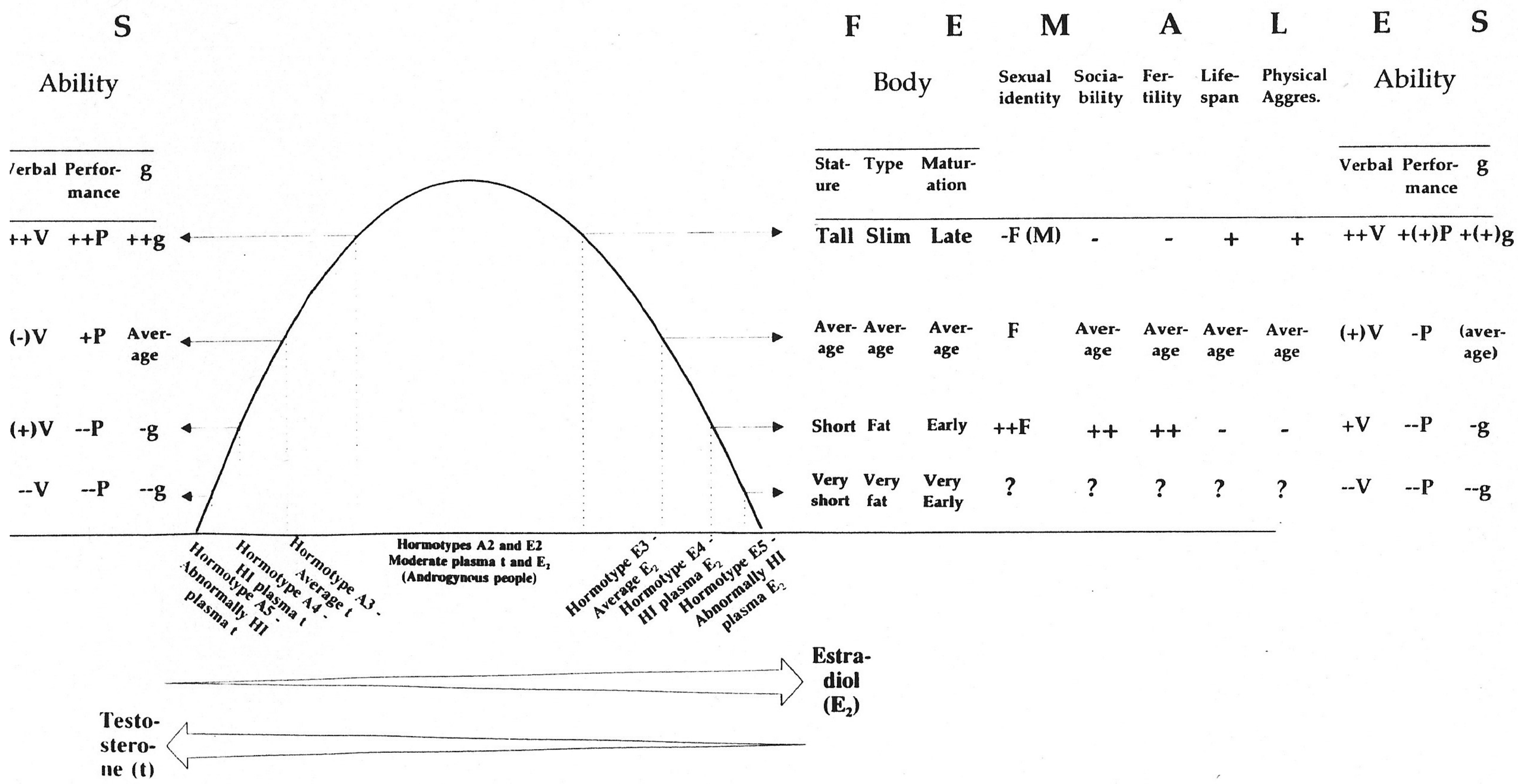

fferent male and female trait covariance patterns as a function of hormotype (see text) in accordance with the

drogen / Estrogen (GTC - A/E) model for development (Modified from Nyborg 1979; 1983; 1984; 1987b; 1988a; 1990b;