MOTHER SUPERIOR?

The biological effects of day care

The relative effects of stay-at-home mothering and institutional day care on the mental and physical development of toddlers have long been debated by psychologists. Here **Dr Aric Sigman** takes a novel and neuroendocrinological perspective

The accepted starting point for any national discussion of childcare is one of a "work-childcare balance" involving "affordable day care". Even many of those forging academic careers in the study of day care are apparently being held back by their own young children. "Tiny tots can prove formidable foes to a woman's academic career aspirations... The shortage of high-quality, affordable day care is enough to make academic parents cry," states a Special Report in *Nature* (Gewin 2005).

Half of British mothers go out to work before their child is 12 months old (OECD 2011). As a result a vast and growing proportion of children under three now attend day nurseries and both the UK and the US have nationalised day care programmes (Sure Start and Head Start).

A recent report by the EU Commission stated that in order to solve Europe's labour problems, many more mothers should return to work early. Commission President José Manuel Barroso said we "should look at the example of the northern countries" and create more childcare places for mothers of young children (EU 2011). A new OECD report *Doing Better for Families*, representing the policy strategy of 34 industrialised countries, concluded: "It is crucial to mobilise maternal labour supply more effectively", adding that "from a career perspective alone, women are probably best advised to go back to work at an early stage after childbirth" (OECD 2011).

But day care is an evolutionary novelty bearing no resemblance to childcare throughout history or in modern traditional societies (Konner 2005). Understanding the effects day care has on children has been hindered by bitter politicised arguments involving women's rights, governmental desire for economic growth, maternal guilt and the media's portrayal of day care study findings. Some researchers who have voiced concerns about the effects of day care have been attacked, while others have suddenly found their research data re-analysed prior to publication (Belsky 2001; Henry 2006; James 2010). However, the uncomfortable question remains – which is better for a young child during weekdays: the biological mother or a paid carer at an institution?

BIOGRAPHY

Dr Aric Sigman CBiol FSB is a Fellow of the Royal Society of Medicine and Associate Fellow of the British Psychological Society. He has travelled to various cultures, including Republic of Congo, North Korea, Bhutan, Tonga, West Papua, Burma, Iran, Korea, Vietnam, Borneo, Mali, Bolivia, Burkina Faso, Sumatra, Cambodia and Eastern Siberia to study families and child development.

> **"One report suggests 70 to 80% of children in centre-based day care show ever-increasing levels of the stress hormone cortisol throughout the day"**

Until now, research on the effects of day care has been dominated by child psychology and social work, focusing on later outcomes for the child such as language skills at age five or six. But what has proved elusive is an understanding of how the young child is affected emotionally and biologically, and how they experience day care while they are actually there. Babies can't speak and toddlers have limited verbal abilities when it comes to describing their inner world. However, research methods from the biosciences are starting to provide an illuminating glimpse of this unspoken landscape, with the child's neuroendocrine responses helping to shed light on their experience. And those responses paint a very different picture to that presented by the day care research establishment: there is something about attending day care for an extended time, whether small-scale and home-based or large-scale and centre-based, that often triggers stress in young children.

The University of Minnesota College of Education and Human Development reports that in many cases, 70 to 80 percent of children in centre-based day care show ever-increasing levels of the stress hormone cortisol throughout the day, with the biggest increases occurring in toddlers. Yet by age five, children don't exhibit these stress reactions to being with other children all day (Gunnar 2010; Vermeer and van IJzendoorn 2006). Of central concern is that the routine stress experienced at day care could cause permanent changes in the child's neuroendocrine networks, with long-term consequences for their mental and physical health as adults.

Until now, such information has remained in specialised journals and has not been widely reported by the national media. By bringing together this under-exposed area of research to form a solid body of evidence, it is possible that society will be able to make more fully informed decisions about the future direction of childcare.

The HPAA axis

The hypothalamic–pituitary–adrenal axis (HPAA) is a system intricately involved in a child's capacity to respond to fear or uncertainty. Neuroendocrine research of stress uses salivary samples to measure cortisol, the steroid end product of the HPAA.

Cortisol levels undergo a diurnal cycle; they peak in the early morning and decline throughout the day. Infants are born without a diurnal cortisol rhythm. They acquire it during their first year of life, and it is subject to programming. Rising cortisol levels are healthy and necessary as an appropriate stress response. However, when stress is chronic, high levels of cortisol remain active in the system and this has significant biological consequences.

For example, increased cortisol exposure is linked to higher numbers of plaques in artherosclerosis of the carotid arteries (Dekker *et al.* 2008). High cortisol levels strongly predict cardiovascular death (Vogelzangs *et al.* 2010). Cortisol is considered neurotoxic and has a global impact on cerebral size (e.g. McEwen 2007; Sheline 2003) and exposure to elevated cortisol levels can lead to structural alterations in the brain's amygdala (Sharpley and Bitsika 2010).

Even subtle dysregulations of the HPAA, such as elevated cortisol levels, have now been implicated in the pathophysiology of stress-related disorders, including depression and anxiety (Ostiguy *et al.* 2011). Cortisol levels at age 17 have recently been used to predict the development of psychiatric disorders during the following

2.5 years (Ellenbogen *et al.* 2011), and a higher cortisol awakening curve may be a biological marker for an underlying disposition towards developing depressive and anxiety disorders (Vreeburg *et al.* 2010). HPAA dysregulation may also offer a biological explanation as to why children with a relatively low socioeconomic environment (SES) are more likely to develop psychiatric and physical illnesses later in life. Chen *et al.* (2010) found that over a two-year period, cortisol levels increased almost twice as much in low SES children compared with those with a higher SES.

Rearing environment and cortisol

There is a close relationship between maternal nurturing and cortisol levels in infants. A study at Sweden's Karolinska Institute found a strong correlation between stay-at-home mothers and child cortisol levels (Stenius *et al.* 2008). Comparisons of different child-rearing environments show low cortisol levels in infants with families who live an "anthroposophic lifestyle" – thought to provide environmental conditions aimed at reducing stress, compared with infants in more conventional families (Stenius *et al.* 2010). Waynforth (2007) reported that, among three- to eight-year-olds, those who slept in the parental bedroom had lower cortisol levels, as did children who attended fewer hours of day care during the first four years of life.

> "In human grey matter, the quality of a mother's care in early childhood is thought to alter the size of the hippocampus"

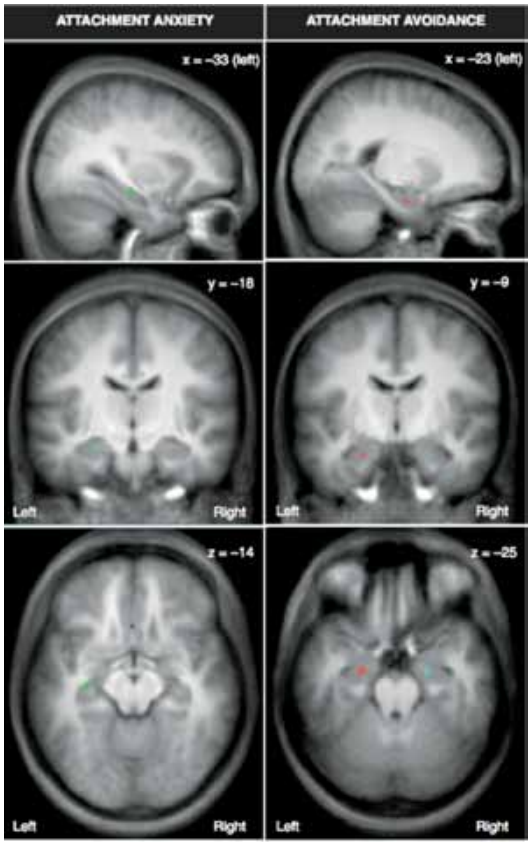


Fig. 1. Insecure Attachment and hippocampal cell density.

A person's approach to close relationships, or their attachment style, is believed to be influenced by early interactions with primary carers, particularly biological mothers. Attachment style has now been linked with waking cortisol levels in female children between the ages of nine and 18. Those with a more "anxious attachment style" had higher levels on awakening and an attenuated cortisol awakening response, the same pattern linked with disorders in adulthood (Oskis *et al.* 2011).

Children who receive less nurturing early in life may be less securely attached as adolescents and adults, with a greater vulnerability to stress. Cortisol may play a key role in the finding that adolescents' attachment orientation influences their diastolic and systolic blood pressure responses to everyday social interactions (Gallo & Mathews 2006).

Early years HPAA programming and grey matter

In the past decade, research has revealed a profound influence of early-life childcare and parenting on the programming of the HPAA and its regulation in adulthood, including the development of the hippocampus and alterations in the cortisol awakening response (Engert *et al.* 2010). In rats, the quality of the mother's care induces changes in the brain's structural neuroplasticity and alters synaptic functioning and the response to anti-inflammatory hormones (including cortisol) and stress.

In controlled experiments, shorter dendritic branch length and lower spine density in CA1 pyramidal brain cells are found in the hippocampi of adult offspring with mothers who were less attentive (Champagne *et al.* 2008). In human grey matter, the quality of a mother's care in early childhood is thought to alter the size of the hippocampus (Buss *et al.* 2007). Attachment insecurity has now been significantly linked to reduced brain size and cell density within the hippocampus (Quirin *et al.* 2010; see Figure 1).

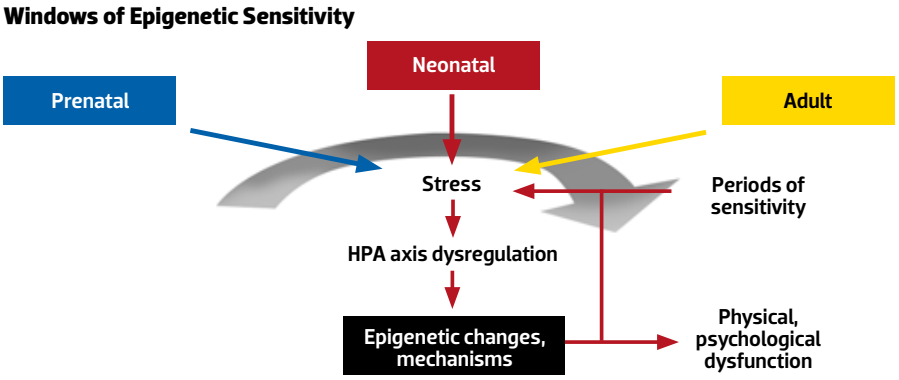
Clusters of grey matter concentration in the hippocampus correlated with human attachment styles. Coloured areas denote lower grey matter concentrations in the left hippocampus found in people with high attachment anxiety scores (left). Lower grey matter concentration in the left as well as in the right hippocampus were found in people with higher attachment avoidance scores (right) (Quirin *et al.* 2010).

In children with a history of maltreatment, raised cortisol levels predict a later reduction in the size of the hippocampus. Neurodevelopmental experiences of elevated stress and cortisol are increasingly seen as a potential cause of reductions in the size of specific brain regions via a cortisol-induced neurotoxic brain cell reduction process (Carrion *et al.* 2007). In early childhood, activity of the HPA axis resulting in cortisol secretion may strain the stress response system, which can in turn have a direct effect on its future ability to function optimally when exposed to additional stress (McEwen 2000a, b).

Epigenetic windows of sensitivity

The mechanisms by which a child's early care experiences are translated into physiological and behavioural changes are now thought to involve epigenetic programming of the HPAA. Mothering plays a central role: maternal care can produce semi-permanent changes in gene expression in brain regions vital in stress response, thereby providing a potential mechanism for early childhood programming of stress-induced disease in adults (Craft and DeVries 2009). In rats, the degree of maternal care alters the offspring epigenome at a glucocorticoid receptor in cells of the hippocampus, as well as altering the HPAA response to stress (Weaver *et al.* 2004; Weaver 2009). Stress occurring during sensitive periods of development might therefore cause lasting changes in the settings and function of the child's HPAA. (Murgatroyd *et al.* 2009; Mesquita *et al.* 2009; see Figure 2).

Elevated levels of stress in young children are of particular concern because a range of developing systems could be adversely affected. Concern is not restricted to high cortisol levels; it includes any dysregulation of the diurnal cortisol cycle or the HPAA more generally. Therefore, a key element in the care of young children is the availability of



adults, particularly parents, to respond appropriately to stress reactions triggered by normal day-to-day events.

Day care and HPAA function

Attending a childcare centre, and the consequent separation from parents, is a significant source of stress for many young children.

A review and meta-analysis of nine studies, *Children's Elevated Cortisol Levels at Day Care*, concluded:

> "Our main finding was that at day care, children display higher cortisol levels compared to the home setting. Diurnal patterns revealed significant increases from morning to afternoon, but at day care only... We examined all papers on possible associations between cortisol levels and quality of care, and the influences of age, gender and children's temperament. Age appeared to be the most significant moderator of this relation. The effect of day care attendance on cortisol excretion was especially notable in children younger than thirty-six months. We speculate that children in centre day care show elevated cortisol levels because of their stressful interactions in a group setting" (Vermeer and van IJzendoorn 2006).

Fig. 2. Epigenetic programming of HPAA. Stress during sensitive periods of child development may cause lasting changes in the settings and the function of the HPAA, leading to physical and psychological disorders later in life.

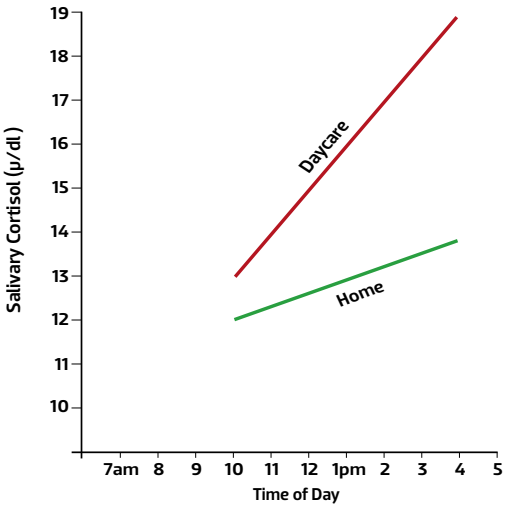


Fig. 3. Compared to cortisol levels at home, increases were noted in the majority of children (63%) at home-based day care, with 40% classified as a stress response, even in day care homes where there were only one or two children (see Gunnar et al. 2010).

Sumner *et al.* (2010) compared children aged between 16 and 24 months on two childcare days versus two non–childcare days, finding that "childcare days were characterized by an afternoon increase in cortisol levels (unlike non–childcare days)". Other studies have compared professional home-based and centre-based childcare. In one, children from professional childcare homes and children from childcare centres in the 20 – 40 months age range were monitored. The study concluded: "Children displayed higher cortisol levels at childcare than at home, irrespective of type of care." (Groenveld *et al.* 2010).

Other studies have assessed the effects of full-time professional home-based day care on HPAA function. Gunnar *et al.* (2010) examined 151 children (3.0-4.5 years) in full-time home-based day care. "Compared to cortisol levels at home, increases were noted in the majority of children (63 percent) at day care, with 40 percent classified as a stress response."

The HPA axis and the immune system are functionally linked. A recent study at Cornell University therefore examined both cortisol levels and antibody secretion among three to five-year-old children "attending very high quality, full time childcare centres". Salivary antibodies provide a critical line of defence against pathogens. Samples were taken throughout the day, both at home and in childcare, to examine the relationship between salivary cortisol concentration and antibody secretion – secretory IgA (SIgA) – and their relationship to childhood illnesses. The researchers found that "a rising cortisol profile at childcare, driven by higher afternoon levels, predicted lower antibody levels on the subsequent weekend".

Of particular note was a decline in antibody production at weekends and on childcare days in older preschool children. They concluded that "elevated cortisol in children during childcare may be related to both lowered antibody levels and greater illness frequency." (Watamura *et al.* 2010).

Stress may activate MHC class II+, langerin+, and CD11c+ immune cells in a child's skin, which can cause inflammatory skin diseases including eczema (Joachim *et al.* 2008). Using the German birth cohort study, Cramer *et al.* (2011) found that, of 11 possible risk factors for eczema during the first two years of life, even years later only "day care centre attendance is associated with an increased prevalence and incidence of eczema."

Others have found that between ages 2 to 3 the cortisol differences between home and daycare are transient and diminish over a year. At 3 years of age, children displayed higher cortisol levels at daycare only if they had a 'later entry', defined as starting after 16 months, while children with more daycare experience, entering before 8 months, showed higher levels at home. (Ouellet-Morin *et al.*, 2010) However, the one year between ages 2 and 3 constitutes one third of a child's life during the greatest period of brain development. And so even if cortisol rises diminish within a year, there has been some systematic dysregulation and subtle lasting effects may have already been set in motion.

And the negative effects of day care may be long lasting. A large-scale study in 2009 involving nine institutions followed approximately 1,000 children from the age of one month through mid-adolescence to examine the effects on later

development of childcare in the first few years of life. Researchers observed children in and out of their homes, and when they reached 15 years-old, they measured their awakening cortisol levels.

Children who spent more time in centre-based childcare during their first three years — whether care of high or low quality — "were more likely to have the atypical pattern of lower levels of cortisol just after awakening when they were 15 years of age, which could indicate higher levels of early stress."

Abnormal cortisol patterns were observed regardless of gender or ethnicity, the family's income level, the mother's level of education or the degree of sensitivity exhibited by parents during the child's teenage years. It is thought that these children may be more prone to stress in their teenage years (Roisman *et al.* 2009).

Quality of care and cortisol

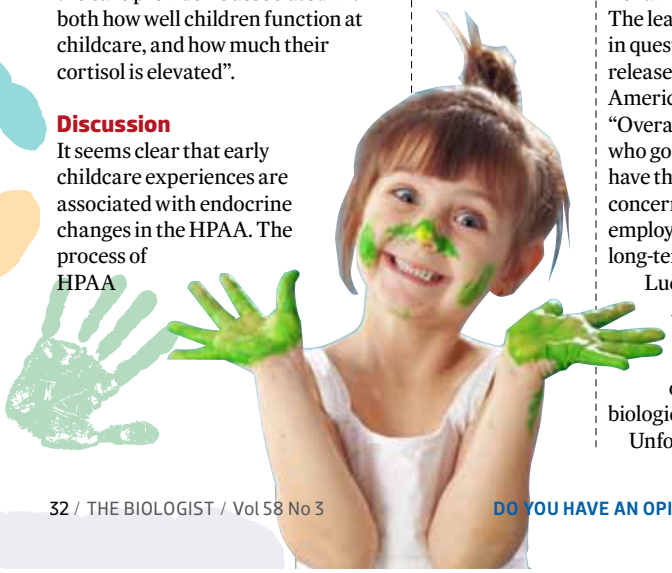
The so-called "quality of care" has been found to modulate some of the relationship between day care attendance and cortisol dysregulation. In the study above by Groenveld *et al.* (2010), lower caregiver sensitivity was associated with higher levels of cortisol during the day in home-based childcare. In centre-based childcare, lower global quality of care was associated with an increase in cortisol between 11:00am and 3:00pm. They concluded: "Quality of care is an important factor in young children's wellbeing and HPA stress reactivity."

The above study on home-based day care by Gunnar *et al.* (2010) also found that increases in cortisol levels throughout the day were influenced by the care provider and activities. The researchers say "the behaviour of the care provider is associated with both how well children function at childcare, and how much their cortisol is elevated".

Discussion

It seems clear that early childcare experiences are associated with endocrine changes in the HPAA. The process of HPAA programming and its effects may be subtle but this does not preclude their significance. If cortisol exposure can be neurotoxic, with adverse effects on both specific neurons and entire neural systems, and some children are experiencing elevated cortisol levels at day care during the first three years of life when the brain will reach approximately 80 percent of its adult size, any consideration of day care attendance must take these factors into account. Since the structure and function of the brain are still developing in children, failure to find consistent HPAA abnormalities associated with day care does not preclude the importance of these systems (Mash and Wolf 2010).

> "Understanding the effects of day care on the child continues to be discussed through the prism of adult sexual politics and women's rights"



And modern life is throwing up further related, if inconvenient, findings. Early child-rearing environment and a less secure infant-mother attachment are now associated with earlier puberty in girls (Belsky *et al.* 2010), as is absence of the biological father. Deardoff *et al.* (2010) found this to be the case only among higher income families and posited that "higher income families without fathers are more likely to have a single mother who works long hours and is not as available for caregiving." The study pointed to "neuroendocrine pathways that influence development", especially cortisol release.

While understanding the effects of childcare involves more than a consideration of neuroendocrine studies, research from the biological sciences continues to be under-reported and under-recognised. However, what is often widely reported and recognized can be found in a recent headline: "Day care Does Not Cause Academic or Behaviour Problems" (Walsh 2010). The lead researcher of the study in question is quoted in the press release from the publisher, the American Psychological Association: "Overall, I think this shows women who go back to work soon after they have their children should not be too concerned about the effects their employment has on their children's long-term well-being." (APA 2010; Lucas-Thompson *et al.* 2010).

Academic achievement and overt behavioural problems are highly prominent outcome measures, while biological variables are not.

Unfortunately, understanding the effects of day care on the child continues to be discussed through the prism of adult sexual politics and women's rights. This has been a significant impediment, involving a serious conflict of interest: women's rights and self-fulfillment are not the same issue as child wellbeing and may often compete for precedence.

If women's rights have been hard won, so too has the ability to publish and discuss openly the inconvenient effects of day care on children. At the same time, curiously, there appears to be little effort invested in concern over the feelings of stay-at-home mothers. As it stands, parental care and day care are presented as equal alternatives entailing mere stylistic differences and choices. Biologically-based research is now providing a very different perspective.

No matter how uncomfortable, society now needs an honest framework in which to make decisions about childcare. Yet there remains a lack of acknowledgment for a dose-response relationship: not just the 'quality' of day care, but the number of hours spent in day care and the age of initiation may affect children. It's almost certainly not a case of more being merrier.

Biology has a vital yet under-recognised contribution to make in this important area of family life and national policy. In future, when policy-making bodies take evidence, biology should be there in the witness box enabling both governments and society at large to make more fully informed decisions. Increased funding for biological research in this area is therefore vital.

Ultimately, decisions about childcare must not be made based upon the limited nature of "evidence-based research". Many fundamental aspects of a child's developmental wellbeing are not accessible through current methods of assessment because they are simply too nuanced or unsuitable.

And so, as we embrace early day care ever further, we should remind ourselves that when it comes to an issue of such fundamental importance we must continue to adhere to that ancient medical imperative "First do no harm", and assume that mother knows best.

More reading and references at
www.societyofbiology.org/biologist

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