Epigenetic Development of Attachment Styles in Autonomous Agents

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Abstract

This poster discusses the theoretical approach to epigenetic development found in Attachment Theory. It then presents autonomous agent simulations which demonstrate how attachment styles may be formed by novel epigenetic processes.

1. Introduction

Attachment Theory is an important theory of emotional development that can be characterised by the disciplines that were brought together in its formulation. This mix of disciplines includes Cybernetics, Ethology, and Cognitive Science (Bowlby 1973). Attachment Theory is therefore described in terms of constructs such as control systems, set-goals, goal-corrected behaviors, and Internal Working Models. This means that it is readily implementable using autonomous agents (Petters 2006, Petters and Waters 2008).

One of the major empirical observations that Attachment Theory attempts to explain is the formation of different Attachment styles. Infants with different attachment styles vary in how they act socially. Some infants are predisposed towards positive attachment behaviours, and these infants are classified as type B - secure. Other infants are predisposed towards negative attachment behaviours, such as emotional avoidance (which are classified type A - avoidant), or resistance (type C - ambivalent). The developmental literature holds a number of theories, which range from nativist to empiricist, that attempt to explain the development of these three different Attachment styles.

Bowlby (1973) was an early contributor to epigenetic thinking in infant development. He used the term homeorhesis to describe mechanisms that can bring about a range of different stable trajectories across the epigenetic landscape for attachment.

2. Simulations that demonstrate the epigenesis of Attachment styles

This work is an example of how stable trajectories that follow Bowlby's process of homeorhesis can emerge in autonomous agents. These trajectories arise due to positive feedback loops operating over many episodes of social interaction between carer and infant agents in a 2D virtual world. In this environment the carer's objectives include foraging for food and responding to their infant agent's requests. Infant agents request social interaction, proximity and physical need, and in addition, when secure, act on their own towards exploration of 'toy' objects.

Figure 1. shows an infant agent architecture based upon Bowlby's (1969/1982) formulation of Attachment Theory which has been implemented using the sim-agent toolkit (Petters 2006). Infant agents with this architecture use their carers as a secure-base from which to explore their virtual 2D environments. The reactive goal selection mechanism is not a 'winner take all' mechanism. The goal activators with highest activation may mutually inhibit each other, leaving a less highly activated goal to direct behaviour, and give the impression of displacment activity.

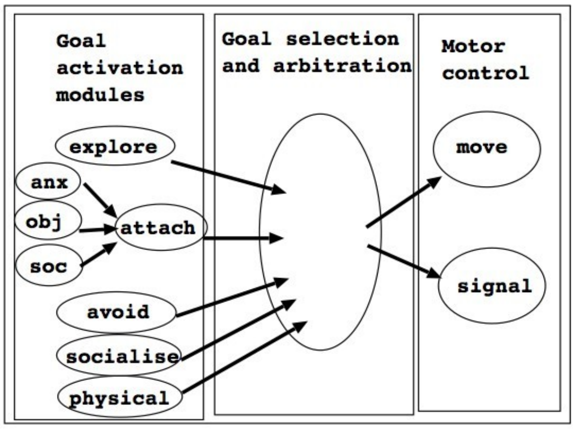

Figure 1, showing a schematic of an implemented infant agent architecture. There are seven goal activators, each with their own perceptual subsystems. These correspond to the goals for exploration (**explore**); anxiety (**anx**); object wariness (**obj**); social wariness (**soc**); physical avoidance (**avoid**); socialisation (**socialise**) and physical needs such as food and warmth (**physical**). The reactive goals of anxiety, object wariness, and social wariness are all combined in a single goal of attachment (**attach**) before they are considered for selection.

The anxiety goal activator (**anx**) possesses a measure of confidence in the carer's responsiveness, that has been implemented as a distance in the 2D virtual world. When the carer agent goes beyond this distance the **anx** levels increase, and this goal is more likely to be selected, and direct motor and signalling actions. Close proximity decreases **anx** levels. Figure 2 shows episodes from two scenarios with contrasting settings of carer-confidence within the **anx** goal activator. The left panel shows a secure scenario, where a B-type infant agent possesses high confidence in the responsiveness of its carer. The right panel shows an insecure scenario, where type A or type C infant agents possess low confidence in the responsiveness of their carer. Note that the carer agents in both secure and insecure scenarios are in comparable positions in relation to their infant agents. It is only differences in the infant agent's internal measures of confidence in carer responsiveness that cause secure infant agents to carry on exploring whilst insecure infant agents use movement or signalling to regain proximity to their carer.

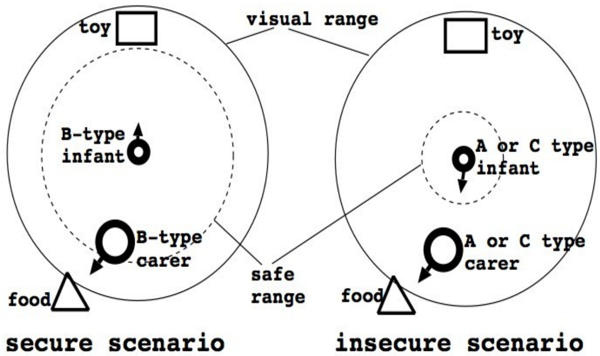

Figure 2, showing two atachment scenarios. A secure infant oves towards a toy as its carer moves away towards food because the carer's position is still within its measure of confidence. When an insecure infant experiences the same event it moves and signals towards the carer to regain proximity.

Computational experiments were carried out on a set of initially identical infant agents that could learn the level of the confidence parameter held in the **anx** goal activator. This measure of confidence was gained from their experience of caregiving responses in episodes when the **anx** goal activator selected for the action of signalling for a response from the carer agent. When carer agents were highly unresponsive infant confidence levels were predictably low. Conversely, when carer agents were highly responsive confidence was high. An interesting result occurred when carer agents were intermediate in responsivess. Over a large number of time cycles all the infant agents developed extremely high or low levels of confidence in their carers. The cause of the bifurcation into two different styles derived from many small random variations in simulation parameters such as carer and infant position. These were transformed and then greatly amplified by positive feedback loops within the many cycles of carer and infant agent interaction. Each time the **anx** variable was changed to be less confident, the chances of the carer failing to act responsively increased. If random initial conditions favoured a few good responses then the learnt confidence level was higher and biased future interactions to be appraised as responsive. These simulations therefore showed a sensitivity to initial conditions, where large differences in outcome can arise from identical agents experiencing very slight differences in environmental conditions.

These novel results show that neither innate differences nor significant environmental differences are needed to bring about multiple, stable and discrete populations of infant agents with different attachment styles from a single class of initially identical infant and carer agents pairs. These results can be contrasted with other results on attachment in social robotics that focus on perceptual processes, such as imprinting (Hiolle and Canamero, 2007), and the creation of robotic comfort zones (Arkin 2005).

In conclusion, this poster presents an implemented simulation that acts as a proof of concept for a novel mechanism of epigenetic personality development, which is within the theoretical framework of epig-enesis and homeorhesis set out by Bowlby over 30 years ago (Bowlby 1969|1982, 1973).

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