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XI. Parent-child interaction under conditions of environmental stress: Exploring the use of neural network simulations

The present study is based on the assumption that our theorizing about parent-child interaction, and on dyadic interaction in general, might benefit from simulations of such interactions using artificial interactants instead of real human beings. Provided that these artificial systems are in key respects similar to the human beings that they represent, such simulations would open possibilities that are not available in research on real-life dyadic interactions. For example, it would be possible to experimentally couple certain types of children with certain types of parents or to experimentally manipulate the pressure of environmental circumstances.

There are several reasons to believe that neural or connectionist networks share enough characteristics with the human cognitive system to make it worth the effort to explore their use in simulations of parent-child interaction. First, neural networks resemble the human cognitive system in terms of how they react to external stimulation. Like the human cognitive system, but unlike traditional computer programs, a network does not need clearly-defined problems or perfect examples of a category to give responses that are at least approximately appropriate. Second, developmental theorists have recently claimed that the human cognitive system, like a neural network, belongs to the class of non-linear dynamic systems (Van der Maas & Molenaar, 1992; Van Geert, 1994). If valid, this implies that human beings, unlike many mechanical systems, are likely to respond non-linearly to gradual changes in environmental stimulation. For interaction research, in which we deal with two systems that do not only respond non-linearly to environmental changes, but also to each other's responses, this implies that gradual changes in environmental pressure are likely to affect the nature of the interaction in ways that are difficult to predict in advance.

Based on the above-mentioned and other considerations (see Olthof, 1995) the present study will use two different varieties of a network representing a parent (further referred to as *MomNet*) who interacts with two varieties of another network representing a child (further referred to as *KidNet*). Both MomNets vary in terms of their *responsivity* to KidNet's responses and both KidNets vary in terms of their *irritability*, that is, they are differentially sensitive to negatively valenced external stimulation.

In this simulation both experimental approaches that were discussed above are combined. That is, four dyads representing the orthogonal combinations of responsive versus non-responsive MomNets and irritable versus non-irritable KidNets, will be examined in terms of how they respond to a gradual increase in environmental pressure.

Method

The simulation consisted of two phases. In the first phase the required KidNets and MomNets were constructed using McClelland and Rumelhart's (1988) bp program. To save space, the details of network construction will be omitted from this report (but see Olthof, 1995). Suffice it to say, that four three-layer back propagation networks were constructed in such a way that the output of one network could serve as the other network's input and vice versa. In addition, an architecture was used that makes the networks sensitive to temporal sequences. By using different training regimes, the MomNets were made differentially sensitive to the KidNet's responses, whereas both KidNets were made equally sensitive to MomNet's interventions, but differentially sensitive to two types of external stimulation. The external stimulation is taken to represent two different sources of negatively valenced environmental stimulation to which KidNet responds with two different types of negative evaluative emotional signals.

In the interaction phase four KidNet-MomNet dyads were formed by coupling the irritable and the non-irritable KidNets to the responsive and the non-responsive MomNets. A testing scheme was designed to assess each dyad's ability to endure increasing pressure from two different environmental sources. Specifically, each dyad was tested using the same 16 sequences of test patterns, each of which contained 47 patterns. Each sequence can be thought of as a period of 47 time units in which a constant environmental source continues to bother the child and in which the parent may or may not succeed in comforting the child. In the first sequence KidNet was confronted with a low-intensity version of one of the two types of external stimulation. In the next seven sequences the intensity of this stimulation was gradually increased. In the remaining eight sequences the same range of intensity values was used for the second type of environmental stimulation. The dependent variable was the time course of the intensity of KidNet's responses within each sequence.

Results

For the dyad consisting of the responsive MomNet and the non-irritable KidNet, all 16 sequences were characterized by oscillating patterns of both KidNet's responses and MomNet's interventions. Although the build-up of KidNet's responses became increasingly faster when situational pressure increased, MomNet was always able to calm down KidNet.

The unresponsive MomNet, in contrast, did not succeed in calming down any KidNet she interacted with. Although the interactions with the irritable and the non-irritable KidNets differed in terms of how fast the KidNets' responses increased in intensity, the non-responsive MomNet intervened in both cases too late and too weak to substantially affect the KidNets' responses.

When dealing with the irritable KidNet's responses to one type of external stimulation, the responsive MomNet succeeded in calming down KidNet for all intensity levels. With the second type of external stimulation, however, the interaction in this dyad changed dramatically depending on the intensity of the external stimulation. The most interesting se-

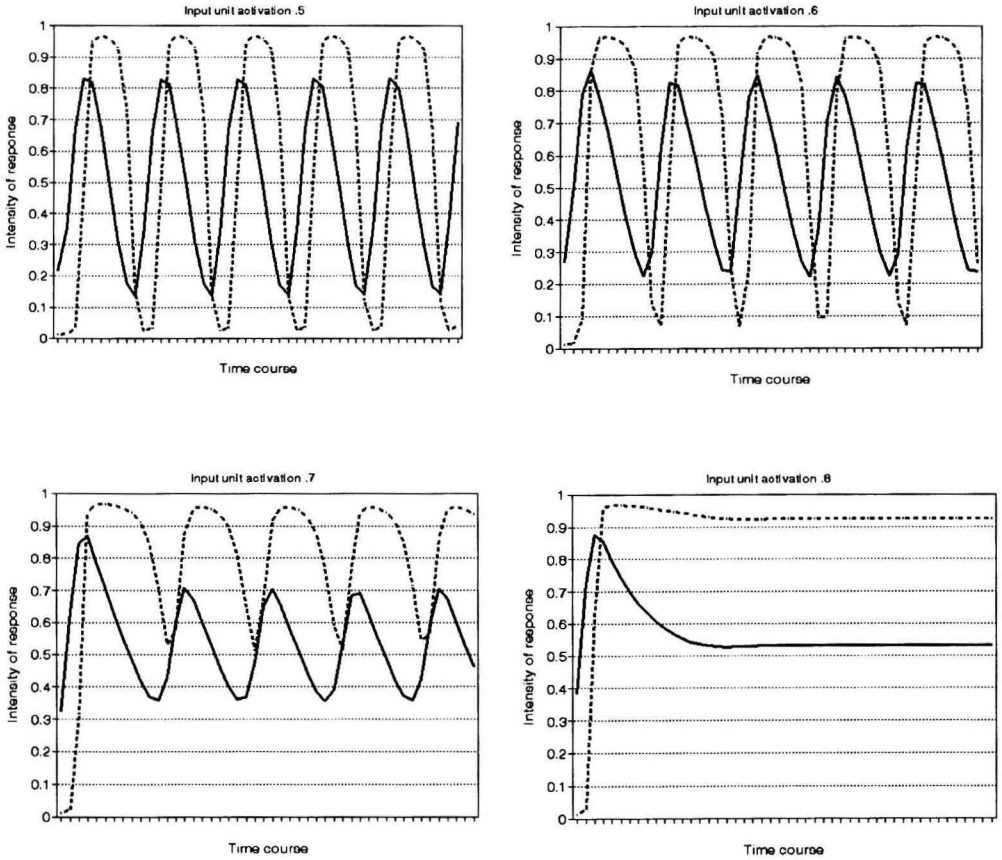

Fig. 1. The time course of the irritable KidNet's responses to the combination of constant environmental stimulation and the responsive MomNet's interventions, as a function of the intensity of the external stimulation. (Solid lines = KidNet's response; dashed lines = MomNet's intervention).

quences from this range are presented in Figure 1.

As can be seen in Figure 1, as long as the environmental pressure did not exceed the intensity level of .6, MomNet was reasonably successful in calming down KidNet, but in the range between .6 and .8 the pattern suddenly changed. From .8 onwards MomNet's interventions were no longer sufficient to calm down KidNet and both networks ended in emitting a stable pattern of high intensity responses.

Discussion

The most important conclusion is that it does seem to be possible to use neural networks to simulate dyadic interaction. The networks' characteristics and the experimental manipulations were only

intended as rough approximations of some theoretically relevant variables. I do not claim, therefore, that the obtained results are in any way substantially relevant to the field of attachment research. Nevertheless, the results seem to be sufficiently plausible and interesting, to warrant further attempts to fine tune the characteristics of the networks and the experimental manipulations to the needs of the field.

References

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