Use of goals and dramatic elements in multi-agent platform for behavioral training of children with ASD

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Abstract
We describe the development of a multi-agent platform and adequate games that aim to stimulate social behavior of autistic children. User tests with two games, one with emerging patterns and another with goals and dramatic elements were compared. The results show that the children do not play significantly longer with either of the games, when exposed for first time to the multi-agent toy. Interestingly, most of the children recognized the dramatic elements, which makes us believe that by longer exposure and proper guidance children might be tough social skills. Test results are described quantitatively and qualitatively.

Keywords
Autism, interactive games, emergent behavior, social interaction

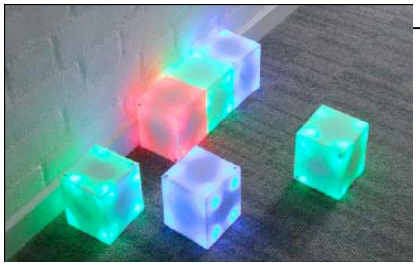
ACM Classification Keywords
J.4 Social and Behavioral Sciences, I.2.9 Robotics, I.2.11 Distributed Artificial Intelligence.

Introduction
Technological toys were shown to be very appealing for children with autism [1,5,8]. Robots, in particular, have been used for behavioral training for autistic children because of several reasons. First, autistic people like

computerized games, predictable behavior, and repeating movements. In addition, developments in robotics during the past two decades have brought to autonomous or tele-operated robots that can act in unstructured environments. Pioneering work in using robots for autistic care has been conducted by Robins, Dauterhahn and colleagues, see for example [9]. The most recent developments in using robots for autistic care are based on human like robots that interacts with autistic children and variety of interesting experiments has been reported in [9,10,11] among others.

Alternative behavioral therapy through play has been suggested by [2,3]. LeGoff [2] has noticed that children with autism came together to discuss each others LEGO creations. This initiated a systematic study of how playing with LEGO influences the social behavior of autistic children.

We have developed an interactive multi-agent platform with emergent behavior which has shown the potential to enhance the explorative behavior of autistic children [1]. It consists of building blocks that interact when positioned in each others vicinity and emit dimmed colored light as a response to sensing other interactive blocks. As a result the collective behavior of all blocks together is emergence of different changing patterns of colored lights in a systematic manner. Similar to the experiments of using LEGO for enhancing the social skills of autistic children, we use building blocks. Differently, our blocks can interact by detecting their neighbors through the build-in sensors and show behavior in response to their sensory stimulation and learning algorithm. Moreover, their internal organization is very close to the existing commercial whose motor behavior is expressed not through motion, but through lights and sound.



The interactive multi-agent platform

Initially we used the blocks as a multi-agent system with emergent properties. This toy stimulated the explorative behavior in the autistic children and was designed to provoke social interactions. In the current study we want to investigate which elements of toy or the game have the potential to develop explorative and social skills of the autistic children.

Our research in using robots for behavioral training of autistic children differs in two major ways from the existing studies. First, differently from the robotics approach we used a multi-agent system instead of human like robot. As argued before [1], a multi-agent system may be interpreted as analogy with society. Second, differently from [2,3] we introduce interaction between the building blocks, so in a way we animate the LEGO-like game.

Platform and game development

In an earlier project [1] we developed a block game which was very well accepted by the autistic children, although the blocks showed just simple emergent behaviors. So we started a more systematic development, distinguishing the platform from the specific games.

By *platform* we mean the hardware, both electronic and physical, including form-giving, sensor, actuator, and programming environment. By *game* we mean a specific embedded program to make the blocks behave according to specified rules, together with the explanation of the rules as to be delivered to the players. The game/platform distinction makes it easier

to develop several games and compare different games on the same platform.

The blocks were specially designed to fit the play habits and the thinking in patterns of the autistic children, but no systematic games were created that might influence the behavior of the children in a positive way. We hypothesize that if the multi-agent system behaviors are designed in an appropriate way, we may be able to more effectively influence and direct the behavior of the children, and eventually enhance their social or explorative skills. Since a change of the skills will be difficult to observe for the period of the conducted project, we designed experiments that show which games instantly provoke more interaction and/or exploration. To test this hypothesis we recorded the amount of social interactions and or explorative behavior (both according to protocols) that will occur during play with the designed games compared to the current behavior of the platform. We created two games. The first game does not involve goal or dramatic elements. The second game has both goal and dramatic elements.

Having dramatic elements in a game is a bit of a contradiction with what the literature says on the abilities of the autistic children to perform believe play [7]. Berk [7] argues that the autistic children will not recognize dramatic elements or even resent them. Even if trying to animate the blocks the autistic children will insist that these are just blocks, and they cannot resemble anything else. Typically developing children of the same age group have developed the skill of believe play [7]. We assumed that including dramatic elements in a game may provide more opportunities to talk about the game, so we proceeded with the experiments.

For this purpose a pet zoo game was developed. The main goal of the game was to care of the animals, which would be represented by animated blocks. In addition, water and food blocks are introduced, which has fading blue and green color, respectively. Each child would control either food or water block that would interact with the animal blocks, or an animal block. This would place the children in the same position, creating a shared focus. Moreover, children are unable to fulfill the main goal all by themselves, they become interdependent [6], and in a way, part of the multi-agent system. The animals would show their state (and thus their needs) by color intensity. A state and transition diagram for the block communication is shown in figure 1.

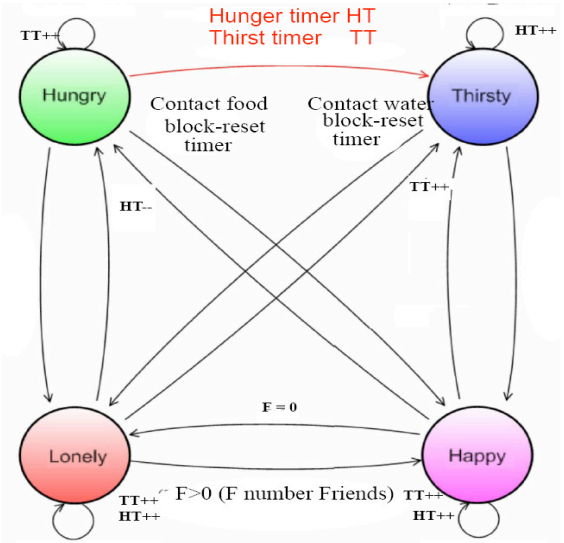


figure 1. State transition diagram

User test

To find measurable entities for social interactions during the play sessions we used a protocol proposed by Legoff [2]. In his protocol measurable instances of social interaction are determined and a specification of which behaviors can be considered as social interaction are made. We conducted the user test according to this protocol. **Participants:** Twelve children, age 7 to 11. Eleven boys and one girl. Six were diagnosed with PDD-NOS, five with classic autism, and one MCDD (multiple-complex developmental disorder). **Materials:** The block platform as described in the previous section with two games, named A and B (also see below). **Procedure:** The children were divided by the care-takers into groups of two. In total 6 teams of two children each took part.

The children participated in two game sessions; one with the existing game (game A) and one with pet zoo game (game B). Half of the teams start with A and half with B for order validity purposes. An important element in this approach is that the way the games are introduced influences the outcome of the test. The way the games are introduced was defined with a strict protocol before both games in order to make the test reproducible. During sessions of A, children were encouraged to create their own game when the playing session died out.

Quantitative results: The filmed test was analyzed to detect the frequency and duration of the social inter-actions. The form was organized in units of ten seconds with labels for the minutes and two parallel timelines, one for each of the two players. Only interactions, where an action (a self initiated social contact) and some noticeable reaction are present, were counted.

The outcomes are shown in the diagram of figure 2 (for each pair the left column is Game B (goals and drama elements) and the right column is A (no goals/drama). N_1 to N_3 and H_1 to H_3 are six couples from two different classes. The difference is positive for 5 out of 6 couples.

A Wilcoxon Signed Ranks test was applied with null-hypothesis H_0 that adding goals and dramatic elements has no influence on the social interaction from the children with the given platform. For N=6, $T^+=17$ so (two-sided) $\alpha = 0.22$. Adopting a significance level of 0.2 the H_0 hypothesis can not be rejected.

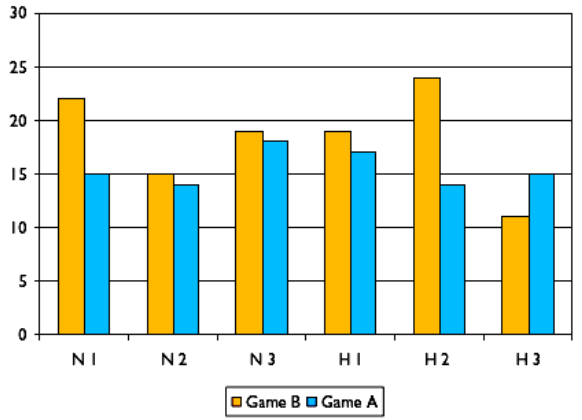


figure 2. Number of social interactions

Qualitative results: We have made several interesting findings. When the children did not have a goal, a discussion about the goal of the game was carried on. This resulted in long sections of interaction. Clarifying the goals made the discussions obsolete for this user group - the players focused on their tasks in the game rather than engaging in longer active social contact. Contrary to other studies, the dramatic elements were

understood by 5 out of 6 teams. The fact that the dramatic elements appear to be understood by most teams is promising for game design. Also the discussions (being social interactions) about the game goal are a cue for game design.

Conclussions

First, we conclude that if combined in an appropriate setting, dramatic elements are understood by autistic children. Contrary to the studies suggesting the opposite, the pet zoo game worked out remarkably well, both as a concept and as a practical game. In our design we successfully married the formal state-machine based behavior (which can be expected to appeal to the autistic children) to the dramatic elements (which are assumedly harder for autistic children).

The second conclusion concerns the way in which the games elicit social interaction. The original idea was that the children would observe the "social" behavior of the blocks and then easier understand real-life social behavior (taking a cognitive detour to do what non-autistic people partly achieve through empathic and natural social skills). Although this still may be the case, what we observed was that it was the discussion of the precise goals of the game and the ongoing interpretation that lead to active interactions among the players. In game B, the vocabulary of very concrete terms (hungry, thirsty, etc.) was instrumental for that purpose.

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