

# Kindergarten Children's Perceptions of "Anthropomorphic Artifacts" with Adaptive Behavior

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## Abstract

In recent years, children from a kindergarten in central Israel have been exposed to learning experiences in technology as part of the implementation of a curriculum based on technological thinking, including topics related to behaving-adaptive-artifacts (e.g., robots). This study aims to unveil children's stance towards behaving artifacts: whether they perceive these as psychological or engineering entities. Hence, their explanations were analyzed looking for their use of anthropomorphic or technological language. In contrast with previous findings, which reported on kindergarten-age children's tendency to adopt animistic and psychological perspectives, we have observed that the engagement in constructing the "anthropomorphic artifacts" behavior promoted the use of technological language and indicated the early development of a technological stance. The implications of the findings for the development of technology-related learning tasks in the kindergarten are discussed.

**Keywords:** technological thinking, adaptive artifacts, anthropomorphic language, kindergarten, control technology

## Introduction

In recent years, children from kindergartens in central Israel have been exposed to learning experiences in technology as part of the implementation of a curriculum on technological thinking. The curriculum has been developed upon the idea that technological thinking integrated into the kindergarten's culture will stimulate the children's curiosity and will support, and even demand, the use of higher-order thinking, analytic capabilities, abstraction, and problem solving, laying out the road to knowledge building processes and learning. The demand for such technological-thinking related skills is not usually part of the curriculum in Israeli kindergartens. A unique strand within the implemented curriculum deals with the issue of 'smart artifacts' - computer

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controlled adaptive systems. Children are exposed nowadays from a very young age to controlled technological systems. A visit to the nearest shopping centre introduces them to automatic doors, escalators, anti-theft security equipment, or automated control gates in parking lots. Many toys they play with are programmable, and at home they interact with complex tools and devices, e.g., remote-controlled appliances, mobile

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phones, and computers. Children are born into a technological world comprising a wide range of smart artifacts; hence, it is only natural that the kindergarten's learning environment embraces these advanced technologies as well.

The rationale of this study addresses the fact that while smart artifacts and robotic systems are being increasingly adopted as educational resources in many kindergartens, key questions deserve still to be examined: What do we know about children's understanding of artificial-adaptive behavior? What developmental affordances and constraints support or restrain children's understanding? What understanding and skills does the interaction with the robotic systems promote? How might systematic knowledge about children's understandings and capabilities help for planning mindful integration of robotic systems as educational tools? In our studies with kindergarten children we address these and similar questions - this paper reports our findings about children's stance towards programmable artifacts with adaptive behavior.

## Background

The ambiguous status of computational objects among artifacts was studied in a series of works. In van Duuren & Scaife's study (1996) artifacts with different anthropomorphic features, i.e., interactive and adaptive behaviors that can be interpreted by children as psychological reality and a person, were used to elicit children's associations as regards to issues such as mental acts of dreaming; motor acts of walking; sensory acts and feelings; and even the very question as to whether the objects have a brain. While children's ideas about a doll, book, and person did not show any developmental differences, the "clever artifacts" – a robot and a computer – showed developmental differences. By the age of 7 years, children construe such intelligent machines as cognitive objects.

Along similar lines, Francis and Mishra (2008) asked children (aged 3 to 8) to interact with "anthropomorphic toys" of three types – a stuffed dog, a mechanical cat, and a robotic dog – varying in level of complexity of their observable functioning. They requested children to tell if these are "real" and to interact with them. They report on differences between the children's verbal descriptions, mostly acknowledging the ontological reality that these are not real, and their behaviors, indicating confusion concerning the reality of the robotic dog – the most sophisticated toy. As well, they report on extensive use of anthropomorphic language as opposed to non-anthropomorphic language.

Ackermann (1991), in describing children and adults' understanding of controlled systems or self-regulating devices, proposes two perspectives: psychological and engineering. The psychological point-of-view conceives intelligent artifacts as living creatures, attributed with intentions, awareness, personalities, and volition. The engineering point-of-view is typically used when building and programming a system. From this perspective, no intentions are ascribed to the system and its behavior is conceived as arising from interactions between its components and between it and its surroundings. As well, there is no need to go beyond the system's material parts. Thus, Ackermann separates between a physical-causal and a psychological-animate perception of behaving artifacts.

However, in most previous studies (e.g., Diesendruck, Hammer & Catz, 2003; Francis & Mishra, 2008) the participants were requested to observe and/or to interact with behaving artifacts – and were not involved in constructing their behavior. As well, the focus has been on the use of anthropomorphic language (e.g., van Duuren & Scaife, 1996), and less attention has been put on the nature of non-anthropomorphic descriptions generated by the children, i.e., descriptions indicative of children's "intuitive engineering" (Pinker, 1997).

In previous studies (Levy & Mioduser, 2008; Mioduser & Levy, 2010) we have already reported about the contribution of the involvement in constructing an artifact's behavior to children's de-

velopment of a technological (i.e., engineering) perspective. In this study we refined the focus addressing children’s explanations of “behaving” (thus potentially anthropomorphic) artifacts **as a function** of their involvement in programming the artifact’s behavior. We focus on two questions:

*Question 1: What is kindergarten children’s **stance** towards programmable adaptive artifacts as reflected in the language used in their explanations?*

*Question 2: Does children use of **anthropomorphic language** vary as a function of the complexity of the task and their involvement in programming the artifact?*

## Method

### Population

Participants were 10 children, 5 boys and 5 girls, arbitrarily chosen from a group of 25 attending a kindergarten of average socio-economic status in the central region in Israel. The kindergarten has been defined for the last five years as experimental, implementing a comprehensive curriculum focusing on technological thinking (Kuperman & Mioduser, 2012). Children’s age ranged from 5.4 years to 6.3 years – average 5.9 years.

### The Robotic Environment

A key research instrument was the robotic learning environment, specially developed for young children (Mioduser, Levy, & Talis, 2009). The environment comprises a physical robot built from Lego pieces, a dedicated Iconic interface, and a progression of tasks of increasing complexity (Figure 1).

The interface allows working in seven modes (shown in the right part of the window). These modes allow:

Activation of the robot in immediate mode, e.g., pressing an action icon such as a ‘turn’ will immediately be executed by the robot (mode 1).

Simple programming of sequences of actions to be performed in immediate (mode 2) or delayed (mode 3) modes.

Programming of routines or packed sets of actions to be reused within other programs (mode 4).

Definition of rules of action linking inputs (from various sensors) with outputs (action instructions) in various configurations: “half rule” (one “If... Then” couple, mode 5); complete rule (“If... Then... Else” definition as in Figure 1, mode 6); two complete rules with four possible combinations between conditions/actions (mode 7).

The iconic interface allows the definition of **control rules** in simple and intuitive fashion. Figure 1 shows a working mode (the active mode appears framed in red) in which a rule of behavior can be defined. Rules are constructed using the iconic elements and take the form “IF [condition] THEN ACTION”. In Figure 1, the conditions relate to two possible states of the light sensor (the bulbs in the upper part): whether it “sees” light or darkness. In the two cells below the bulbs children define the actions by dragging the arrows, e.g., “IF [dark] THEN [turn right]”. Once completed, the program is transmitted to the robot. It can now navigate the task scenarios and behave according to the rule.



Figure 1: “Robogan” – the robotics behavior-construction interface and robotics working area in the kindergarten

## The Tasks

The subjects in our study participated in two types of tasks: description and construction tasks. In a **description** task, the child narrates and explains a demonstrated robot behavior. In a **construction** task the child programs the robot's control rules to achieve a specific behavior. The tasks were sequenced in increasing difficulty by the configurations of rules required to perform tasks. The operational definition of rule-configuration is the number of pairs of condition/action couples. The tasks spanned from the use of one rule (one condition/action couple), the joint use of a rule and a routine (a routine is a packed reusable sequence of instructions), to the use of two inter-related rules (two pairs of condition/action couples). A brief description of the tasks follows.

### A rule task

- For *description*: the robot has to move around an island (an irregular black area) without “falling” into the surrounding water.
- For *programming*: the robot has to guard the palace as a watchman. It has to navigate the internal patio (a white rectangular area) whilst avoiding leaving the area.
- Programming setting: the navigation environment comprises a white square area (the palace's patio) surrounded by a black frame (the surrounding walls); the robot's light sensor is oriented down to the floor.

### Two rules task

- For *description*: The robot is located under a parasol in the seashore. If we put on its “head” (upper touch sensor) a hat, it will move freely at the sea-shore. If the hat is taken off it goes backwards to find a parasol. A light sensor collects information about areas with “sun/shadow” and a touch sensor about the hat.

- For *programming*: the robot has to traverse a bridge (a black strip with irregular path), avoiding to fall into the water. Two sensors allow collecting data about “being on the bridge” or moving either to the right or the left of it.
- Programming setting: On a white surface the bridge is represented by a wide and sinuous black strip. Two light sensors, oriented downwards, collect data independently about black and white areas.

### **A rule and routine task**

- For *description*: the robot pushes a football until it scores. Then it performs a dance like many players do – a reusable routine activated each time a goal is scored.
- For *programming*: the robot has to navigate an area with obstacles. If it reaches an obstacle it will perform a detour routine to get away from the obstacle.
- Programming setting: a navigation area in which numerous obstacles have been placed; a touch sensor in the robot’s ‘front’; there is need for an ‘escape routine’ (embedded within the general navigation rule) to be activated whenever the robot faces an obstacle.

### **Procedure**

Data collection lasted two months. All sessions and interviews took place in the kindergarten’s robotics corner and were videotaped. Based on existing literature as well as on the qualitative analysis of the sessions’ transcriptions, categories for analysis were defined. The units of analysis chosen were statements in which the use of either anthropomorphic or technological language could be identified. About 25% of the data were analyzed by two independent judges, who reached an agreement level of above 85%.

## **Results**

### ***Question 1: What is kindergarten children’s stance towards programmable adaptive artifacts as reflected in the language used in their explanations?***

To address the first question we assessed children’s stance towards smart artifacts as reflected in their explanations and the kind of language used. We defined the use of anthropomorphic language as indicative of a psychological or animistic perspective, while the use of technological language characterizes an engineering perspective. The different types of explanations are exemplified in Table 1.

A total of 844 statements were generated by the children, of which 684 were found relevant to our analyses (the remaining statements were not related to the children’s perception of the robot’s behavior). 107 statements (16%) were articulated using anthropomorphic language, and 577 statements (84%) using technological language. This finding is particularly interesting against the expectations based on previous literature about children’s perceptions of “ambiguous” creatures like robots. In the vast majority of the situations faced by the children, they approached the robot’s behavior mostly from a technological/engineering perspective rather than from a psychological perspective.

**Table 1: Types of explanations using different languages**

<b>Explanations</b>	<b>Definition</b>	<b>Examples of children's explanations</b>
Use of anthropomorphic language	Robot's behavior is explained in terms of intentions, volition, feelings and human-like actions	"... <i>He sees that it is the sea and decides to turn...</i> " "... <i>If he sees a person then he has to tell him...</i> "
Use of technological language	Robot's behavior is explained in terms of its components' functions, mechanisms, and formal decision-making rules	"... <i>we simply wrote [programmed], when he gets to the black area he stops and when in the white area turns back...</i> " "... <i>and if one [sensor] sees white and the other sees black then [turn] left...</i> "

A more refined analysis of the statements showed nuances characterizing the use of anthropomorphisms. In some cases children's phrasings indicate conceptions that are typical to this age level, e.g., "*he has learned to guard*" [the palace]; "*now he knows how to walk*"; "*he did not score a goal... he did not throw any ball*". It should be noted that the Hebrew language has no gender neutral pronouns, such as the English "it" used for designing things. Thus, children make use of the pronoun "he" for referring to the robot even if they perceive it as an artifact.

Many statements indicate children's identification with the robot and describe its functioning in terms of volition and emotions, e.g., "*He's walking only on the white area because it feels warm ... he wears a hat and he knows that he is wearing the hat*".

However most statements were indicative of a technological or "intuitive engineering" perspective. Children referred to structural components of the robots, their functions, and their contribution to the robots adaptive behavior. A sample dialog illustrates this perspective:

Researcher (R): when it is on the black [area] ... what should it do?

E.: Has to go back to the white [area]

R: And if on the white [area]?

E.: Then it goes to the black with its eyes

R.: Then if it is on the white...

E.: Then it goes to the black, afterwards turns to the white, then again to the black

R.: How does it know that?

E.: Because you did it in the computer ... you wrote that black is for sea and white for the land.

An interesting finding is that, in many cases, the use of anthropomorphic language evidenced a **functional** rather than an psychological perspective: within the context of the "story" of the task, and in a colloquial dialogue, children felt more natural to use human-like terms for describing things even if they explicitly acknowledged that they are talking about an artifact's behavior. An example: "*I have left the maze*" [talking about the robot's success in the task] – when further inquired by the interviewer the child added: "*because I've directed him*" [referring to the program he has constructed].

In sum, children's explanations show that they perceive the robot mainly as an artifact able to show adaptive functioning. They use mainly technological language to explain its functioning (obviously within the constraints of their technological knowledge), and the use of anthropomorphisms is in many cases due to functional purposes rather than to a psychological stance towards the robot.

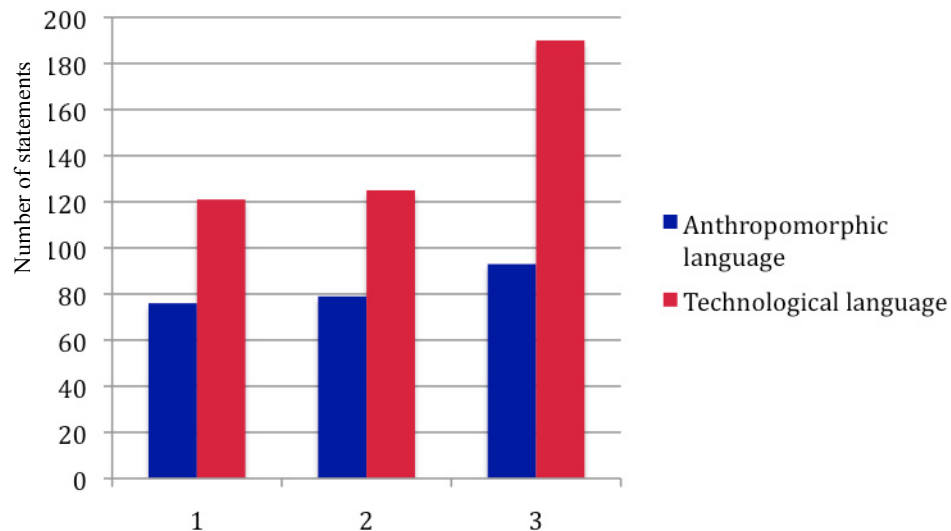
**Question 2: Do children's explanations (and the use of anthropomorphic language) vary as a function of the complexity of the task and their involvement in programming the artifact's behavior?**

A breakdown of the analysis of children's statements by the kind of task performed (i.e., explaining observed behavior vs. constructing the robot's behavior), and its complexity, is shown in Tables 2, 3, and 4 (N-statements=684), and in Figure 2.

**Table 2: explanations' language by complexity level of the tasks**

Task	Anthropomorphic language	Technological language
One rule - N=197	76 (39%)	121 (61%)
One rule + routine - N=204	79 (39%)	125 (61%)
Two rules - N=283	93 (33%)	190 (67%)

As shown in Table 2 and Figure 2, the number of statements **increased** with the complexity of the tasks. At the same time, the distribution of anthropomorphic and technological statements remained similar along the tasks: one third and two thirds correspondingly.



- 1: One rule - N=197  
 2: One rule+routine - N=204  
 3: Two rules - N=283

**Figure 2: Children's perception of the robot's behavior as a function of task complexity**

Figure 2 shows an increase in number of statements and the increasing gap between both types of statements is illustrated.

**Table 3: language used by children to describe the activity in the tasks**

Activity	Anthropomorphic language	Technological language
Observation - N=107	54 (50%)	53 (50%)
Construction - N=577	194 (34%)	383 (66%)

**Table 4: language used by children by task level and activity**

Task	Activity	Anthropomorphic language	Technological language
One rule	Observation - N=44	21 (48%)	23 (52%)
	Construction - N=153	55 (36%)	98 (64%)
One rule + routine	Observation - N=41	19 (46%)	22 (54%)
	Construction - N=163	60 (37%)	103 (63%)
Two rules	Observation - N=22	14 (64%)	8 (36%)
	Construction - N=261	79 (30%)	182 (70%)

In Table 3 it can be seen that “constructors” generated **five times** more statements than “observers”. Altogether, the statements generated by the “observers” were similarly distributed concerning the use of anthropomorphic and technological language (50%). The statements generated by the “constructors” were predominantly of the technological type (about two thirds).

With the increase in tasks' complexity, the use of anthropomorphic language by the “observers” increased and by the “constructors” decreased. At the same time the use of technological language by the “constructors” remained at a similar level – about two thirds of the statements (Table 4). For the more complex task (two rules), the “observers” generated a small number of statements, of these mostly using anthropomorphic language. For this task the “constructors” generated the largest number of statements, mostly using technological language.

It results clear that the involvement in constructing the robots' behaviors affects the richness of children's explanations (reflected in the number of statements), and their content – directing their focus to the technological features of the artifacts' functioning and adaptive behavior.

In contrast with previous findings, which reported on kindergarten-age children's tendency to adopt animistic and psychological perspectives, we have observed that the engagement in constructing the “anthropomorphic artifacts” behavior promoted the use of technological language and indicated the early development of the engineering stance.

It seems that technological language is needed for addressing tasks of increasing complexity, both for understanding and explaining the artifacts behavior **and** more evidently for programming it.



## Discussion and Implications

This study follows a number of studies conducted by us in recent years (Mioduser & Levy, 2010) with preschool children, aiming to examine use of kindergarten children's perceptions and understanding of behaving adaptive artifacts.

Preschoolers' encounter with robots challenges their perception of the distinction between human behavior (characterized by, e.g., volition, motivation, emotions) and artifactual behavior, when it shows features normally associated with human behavior, e.g., acting, navigating spaces, making decisions (Epley, Waytz, & Cacioppo, 2007).

This study has shown that with the increasing complexity of the tasks, children's perception of the robot moves from a psychological perspective (as a human being or animal) as manifested in the use of anthropomorphisms, towards a technological perspective. Dealing with more complex tasks requires the use of analysis and interpretation skills, and planning and performing skills, focusing on the actual structural and functional components of the robot. Thus, the anthropomorphic perspective focusing more on the observable behavior is displaced in favor of a technological perspective focusing on the causes of the behavior.

But even in the anthropomorphic descriptions, it is evident that the children do not think of the robot as human. They attribute human characteristics to the robot to formulate expressions that help them to describe and explain its functioning and behavior.

The study has several implications at both the theoretical and practical/pedagogical levels. At the theoretical level, we have expanded our understanding of how children's involvement in tasks affording activities at the same time symbolic (i.e., reflecting on the artifact's behavior; working with the iconic interface) and physical (i.e., manipulating and observing the behavior of a real artifact) supports their thinking and acting beyond the anticipated in the developmental literature for this age level. Facing the need to construct the robot's real behavior in the physical environment, children engage in complex tasks at a level of abstraction that is challenging for preschoolers: analyzing the required behavior; thinking about the components of this behavior; defining causal connections (e.g., between input data and actions); developing strategies to cope with the complexity of the task and composing the symbolic representation of the program that might generate the required behavior; evaluating the symbolic solution, and debugging it if needed, against the real performance of the robot.

As well, we have observed that while approaching the "breed" of behaving and adaptive artifacts children very rapidly adopt appropriate (even if not accurate or correct) language and explanatory approach. Epley et al. (2007) suggest that because social experience in early human life is primarily with human agents, understanding of non-human agents in non-anthropomorphic terms should develop later. A key condition for the development of a non-anthropomorphic stance is the parallel construction of alternative representations of non-human agents, resulting from increasing direct or indirect experience with these agents. We believe that the active interaction with robotic agents, at the level of involvement in the construction of their behaviors as afforded in our study, implies a powerful opportunity for the development of alternative and non-anthropomorphic understanding of the features of non-human agents by the preschoolers.

The new technological landscape in which the children are immersed (quite different from landscapes within which previous research on children's perceptions and developmental capabilities was conducted) seems to challenge their curiosity and affects the quality and content of their understanding and explanations as observed in our studies. The insights obtained about children's understandings should guide the creation of authentic, situated and challenging learning tasks incorporating the new sophisticated landscape.

Thus at the practical level, the learning environment – computer interface and learning tasks – has proved to be a powerful tool supporting children's construction of knowledge. The learning environment affords, and even demands, switching between the physical and the symbolic, the concrete and the abstract: the actual behavior and the symbolic representation of its components and causes. The lessons learned from our studies might serve as guidelines for continuing the development of the learning environment and the further design of sets of learning tasks. The pedagogical approach and sets of tasks implemented in the studies have found their way to regular kindergartens and are being implemented in an increasing number of sites in Israel.

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## Biographies



**Asi Kuperman** is a Ph.D. student in Tel Aviv University's School of Education. She has worked for many years as kindergarten teacher (actually head teacher due to the characteristics of the kindergarten system in Israel). For the last seven years she is involved in the implementation of a curricular model focusing on "technological thinking" in the kindergarten, in a number of kindergartens in Israel. Her dissertation concentrates on a close examination of children's perceptions of-, and ability to program, simple robotic systems with adaptive behavior.



**David Mioduser** is a Professor of Science and Technology education in Tel Aviv University's School of Education. He heads the Science and Technology Education Center, a R&D center within which numerous projects studying the integration of advanced technologies into teaching and learning processes are being conducted. The focus of his research is on cognitive aspects of the encounter between learners and technology. In the last ten years his studies address young children's technological thinking, and their ability to manipulate complex technologies, in particular controlled artifacts with adaptive behavior.