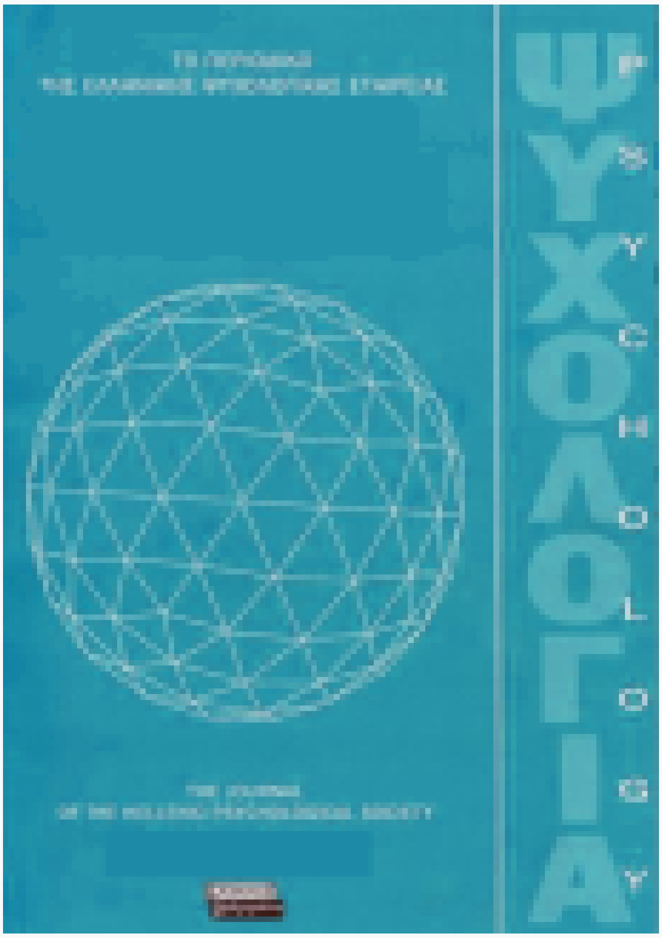
Psychology: the Journal of the Hellenic Psychological Society

Vol 10, No 1 (2003)



Attributing human properties to computer artifacts: Developmental changes in children's understanding of the animate-inanimate distinction

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doi: 10.12681/psy_hps.23951

To cite this article:

A. Mikropoulos, T., Misailidi, P., & Bonoti, F. (2020). Attributing human properties to computer artifacts: Developmental changes in children’s understanding of the animate-inanimate distinction. *Psychology: The Journal of the Hellenic Psychological Society*, *10*(1), 53–64. https://doi.org/10.12681/psy_hps.23951

Attributing human properties to computer artifacts: Developmental changes in children's understanding of the animate-inanimate distinction

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ABSTRACT In the last twenty years, the objects in children's lives have come to include "intelligent" machines such as computers and robots. Answers to questions about children's developing ability to make the animate-inanimate distinction must thus be renegotiated in the context of these new artifacts. We report a study about the attributional judgements of 54 children aged 3-5 years, to a person, a robot, and a computer. Questions were asked about these items': (i) unobservable internal properties, ability to (ii) initiate action, (iii) have mental states, (v) experience emotions, (vi) bodily sensations and, finally, (vii) their life status. The results showed a clear difference in response patterns for the three test items. At all ages participants demonstrated a coherent understanding of the properties of humans. In contrast, they tended to attribute animate properties to the two computer artifacts. Robots attracted more animistic attributions than computers. The results also indicated that with older age children's animistic attributions give way to a fuller awareness of the nature of computer artifacts.

Key words: Animate/Inanimate distinction, Computer artifacts, Developmental changes.

The young child's developing concept of life has been the subject of inquiry by psychologists for several years. Piaget (1929) was the first developmental psychologist to ask when children begin to characterize various objects as animate or inanimate. Unlike adults, young children often attributed animate properties to inanimate objects, a phenomenon to which he referred as childhood animism. He proposed that children progress gradually from a level of fundamental confusion (a mixing of animate with inanimate objects) (Stage 0) to a series of four levels of understanding that are in accordance with the developmental stages of his theory[1]. More specifically, children first restrict the attribution of life to objects that show activity or have a function (Stage 1, up to age 6), then to objects that move (Stage 2, age 6-8), then to objects that move independently (Stage 3, age 8-12) and finally to animals and plants by the application of biological criteria (Stage 4, 12 years and beyond).

Piaget's proposal of childhood animism has been criticized on many grounds. For instance, a growing body of experimental research has

1. Pre-operational, concrete operational and formal thought.

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presented evidence showing that from preschool age children begin to treat animate things differently from inanimate ones. Properties such as inheritance (Springer, 1992; Springer & Keil, 1989), growth (Carey, 1985; Gelman, 1993), internal structure (Gelman, 1990; Gelman & Wellman 1991; Simons & Keil, 1995) and autonomous action (Gelman, 1990; Gelman & Gottfried, 1996) are used effectively by preschool children to distinguish between these two classes of objects. By age three years, for example, children know a significant amount about the unobservable internal properties of familiar objects. They report typically that animates have blood, bones and organs (such as heart and muscles), whereas inanimates have either nothing or have material such as cotton, paper, hair and "hard stuff" (Gelman, 1990; Simons & Keil, 1995). Studies have further shown that three and four-year-olds understand that animate, but not inanimate objects, move as a result of self-generated powers (Gelman, 1990; Gelman & Gottfried, 1996). These findings, then, contrast to Piaget's (1929) claim that children under six years are adhered to animism.

However, children's initial understanding of the animate-inanimate distinction may not go very deep. Evidence for this position can be found in a broad array of studies showing that children at age four to six years attribute bodily sensations (e.g., feeling cold and feeling pain) to plants and inanimate objects (Hatano & Inagaki, 1987; Hatano, Siegler, Richards, Inagaki, Stavy, & Wax, 1993), judge that cars, tulips and cherry trees are equally alive (Ochiai, 1989), and ascribe mental properties (e.g., thought and feelings) to primates, other mammals, birds, reptiles and fish (Coley, 1995). These latter findings are inconsistent with recent evidence corroborating that by age four years children develop a theory of the mind (i.e., an understanding that other humans and ourselves act on the basis of beliefs and desires; for reviews see Flavell & Miller, 1998; Mitchell, 1996). They suggest that children, in the preschool years, may not distinguish between classes of objects with or without minds.

To explore further children's developing ability to make the animate-inanimate distinction, an interesting context would be to study their views about the nature of computer artifacts. Designed around animate metaphors, computer objects take on many of the properties previously reserved for the human kind (Keil, 1992). They can perform several sophisticated functions such as cognitive tasks (e.g., problem solving computers) as well as sensory-motor activities (e.g., sensing and moving robots) (Scaife & van Duuren, 1995). These properties make them not readily categorizable as either animate or inanimate (Keil, 1992; Travers, 1996). In fact, they are not a few those who envisage a continuum

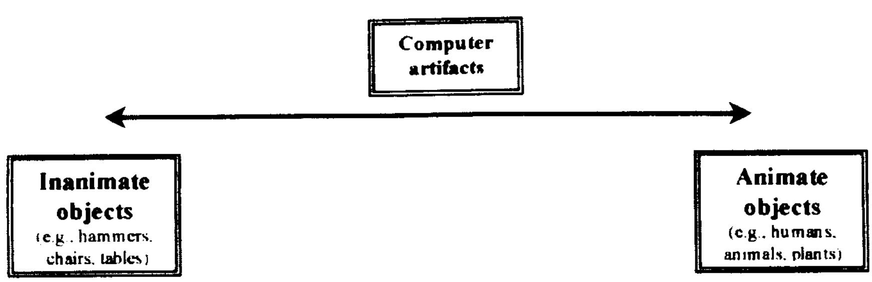


Figure 1
The animate-inanimate continuum.

(see Figure 1) between life and non-life, with computer artifacts standing in between (Levy, 1992; Turkle, 1984; van Duuren & Scaife, 1996).

Notwithstanding the dilemma of where to position computer objects along the animate-inanimate continuum, it is difficult not to commit oneself to a set of assumptions as to what their "essential properties" are. Gelman and Spelke (1981) have proposed a set of key-properties that seem to characterize animates. Unlike inanimates, animates (1) can initiate action, (2) have a particular internal structure, (3) have mental states (e.g., beliefs and desires) which influence their behaviour, (4) experience e-motions (e.g., happiness and sadness) and bodily sensations (e.g., pain). Based on this account, it may be possible to list some of the properties that are fundamental to computer artifacts, such as computers and robots. Computer objects do not act autonomously, possess specific internal parts (e.g., wires and microchips), do not have mental states, neither they experience emotions and bodily sensations[2] (Travers, 1996).

The question then becomes at what age will young children begin to distinguish computer artifacts from humans on the basis of these properties? The few studies that sought to investigate this question have revealed that preschool children may attribute human properties to computer artifacts. An early study by Ochiai (1989) reported that the majority of the 6-year-old children in his study attributed life to robots. Another more recent study by Scaife and van Duuren (1995) examined five to eight-year-old children's knowledge about the unobservable internal properties of computers and robots. At age five, children attributed a brain more often to the robot than to the computer. Older children attributed a brain to both artifacts, but they commented on the artificial nature of it. Taken together, the results of these studies suggest that in preschool years the boundary between animates and computer objects may be vague.

The purpose of the present study was to expand on the research done on children's ability to make the animate-inanimate distinction with respect to computer artifacts. More specifically, the study had three goals: (a) to determine whether preschool children are able to distinguish between computer artifacts and humans using as criteria a number of specific properties characterizing (or not) these two classes of objects, (b) to examine whether there are developmental changes in preschool children's understanding of the nature of computer artifacts, by comparing the attributional judgements of three groups of children, three-, four- and five-year-olds, and (c) to investigate the relative weighting on children's judgements of the degree of salient similarity between computer artifacts and humans.

To pursue these goals three stimuli were employed: a person, a computer and a robot. Computers can be said to be cognitively similar to humans. Robots, on the other hand are similar in appearance to humans along with their cognitive resemblance to them. Moreover, they move in ways that are, by design, similar to that of a human (Scaife & van Duuren, 1995). The study also employed an inductive projection task[3] in which children were asked to answer a series of "yes/no" questions as to whether the test items possess properties that are typically animate. Previous research has focused on a few attributes (specifically, life status and internal properties), we instead examined a series of specific properties, which could be divided into 6 clusters, including (1) unobservable internal

2. Albeit it must be emphasized that no simple set of properties can be used to point to as defining the meaning or constituting the essence of computer artifacts.
3. In inductive projection tasks children are asked to judge whether a set of animate and inanimate objects have target properties that are typically true to humans (Hatano & Inagaki, 1999).

properties, (2) autonomous action, (3) mental states, (4) emotions, (5) sensory properties and, finally, (6) life status (being alive).

Set against a background supporting that the ability to make the animate-inanimate distinction is not fully developed in the preschool years (Coley, 1995; Hatano, Siegler, Richards, Inagaki, Stavy, & Wax, 1993; Inagaki, 1989), as well as prior work corroborating the view that children of five and six years may attribute animate properties to computer objects (Ochiai, 1989; Scaife & van Duuren, 1995), we first hypothesized that preschoolers will not fully distinguish between humans and computer artifacts. Second, we hypothesized that this difficulty to make the animate-inanimate distinction with respect to computer artifacts will become less pronounced with increasing age. Finally, a third hypothesis was that children's tendency to attribute animate properties to computer objects would increase in proportion to the target (computer) object's salient similarity to humans. Previous research has supported that young children expect entities that are perceptually similar to humans to share more properties than entities that are dissimilar (Inagaki, 1989; Inagaki & Sugiyama, 1988). We, therefore, predicted that the likelihood to assign animate properties would be greater for the robot than for the computer.

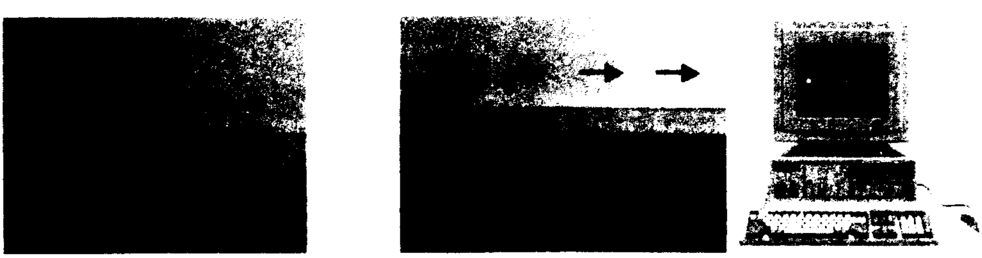
Method

Participants

Participants were 54 children, 28 boys and 26 girls. Age groups were as follows: thirteen 3 to 4-year-olds (range 3:5[4]-3:9; mean age 3:7; *SD* = 1:2); twenty five 4 to 5-year-olds (range 4:1-5:0; mean age 4:5; *SD* = 4:2); sixteen 5 to 6-year-olds (range 5:1-5:6; mean age 5:3; *SD* = 1:6). Sexes were almost equally represented in all age groups. Children were drawn from four local nurseries in the city of Ioannina and were tested during regular school hours. The sample represented a wide range of socioeconomic backgrounds.

Test items

Three test items were used. A woman, who served as an example of the category "person". A personal computer and a remote-controllable robot which served as stimuli in the category "computer artifacts". The robot was approxi-



Person Robot Computer

Figure 2
Test stimuli.

4. Years: Months

mately 60 cm in height and was made of gray plastic. It was like a person in that it had a head, arms, hand-like grippers and a body. It moved about on wheels that were not visible. The personal computer was one of those usually used in schools. The three test-items are presented in Figure 2.

Materials

Three standard Polaroid color photographs, two video vignettes and a computer program were the materials of this study. The pictures (14 x 16 cm) depicted each one of the test items. They were used in an identification task at the outset of the study and served as memory aids, presented along with the test questions throughout the procedure. Two video vignettes were also created. Each vignette lasted approximately 30 seconds. The first showed the woman walking a distance of approximately 5 feet in length and standing still at the end. The second showed the robot walking about the same distance standing also still at the end. The robot was remotely controlled by one of the experimenters so that on the videotape its movement appeared to be self-propelled. Finally, a computer programme was prepared using an IBM compatible computer and LOGO programming language. This programme presented a circular disc moving on a horizontal line for a period of 9 seconds across the computer screen.

Procedure

Children were tested individually in a single session lasting approximately 15 minutes. Each participant was first shown pictures of a person (woman), a robot and a computer and was asked to name them. Next, children saw the video vignettes. Finally, they were presented with the computer program.

Following the presentation of each vignette and the computer program, participants were asked 8 questions (see Table 1) about the stimuli, illustrating the presumed differences between humans and computer artifacts outlined in the introduction. For example, with regard to the structure of the test items, children were asked: "Does X have a brain?" There was also a life judgement: "Is X alive?". The test-questions about the presence of the signified properties were asked in a different random order for each object, with the restriction that the life question was always presented last. This was done in order to minimize the influence of the life judgement on participants' responses concerning other properties.

Table 1
Test questions

Property	Questions
Internal structure	Does X have a brain?
	Does X have a heart?
Action	Can X do things by itself?
Mental states	Does X know things?
	Does X want to do things?
Emotion	Does X feel sometimes happy/sad?
Bodily sensation	If we prick X with a needle, will it feel it?
Life	Is X alive?

Results

Pre-test

One of the 3-year olds failed to identify the robot on the picture and was therefore replaced. The rest of the participants did not have any difficulty in naming the test items on pictures.

Aggregate judgements correct

In the analyses that follow children's correct responses on each of the test questions (8 questions in total) were aggregated. The correct answer to the "yes/no" questions for the person was "yes", but it switched to "no" for questions concerning the two computer artifacts. Each child received three scores, indicating the number of times she or he answered correctly per test-item (person, robot, computer). Therefore, scores per test item could range from 0 to 8. Mean percentages of aggregate judgements correct were tabulated and are presented in Figure 3, classified by age group and by test item.

Data were entered into a 3 (age: 3, 4, 5 years) x 3 (type of item: person, robot, computer) MANOVA with repeated measures on the last factor. Two main findings emerged from this analysis. First, there was a main effect for the type of item, $F(2, 102) = 114.981$, $p = .000$. Clearly, judgements regarding the person (mean aggregate percentage correct across age groups = 97) were almost perfectly accurate and these were significantly different from those regarding the robot, $t(53) = -12.957$, $p = .000$, and the computer, $t(53) = -8.657$, $p = .000$. Similarly, accuracy in judgements was significantly different for the two artifacts, $t(53) = -5.316$, $p = .000$. The computer (mean aggregate percentage correct across age groups = 54) seemed overall to elicit more correct judgements than the robot (mean aggregate percentage correct across age groups = 33).

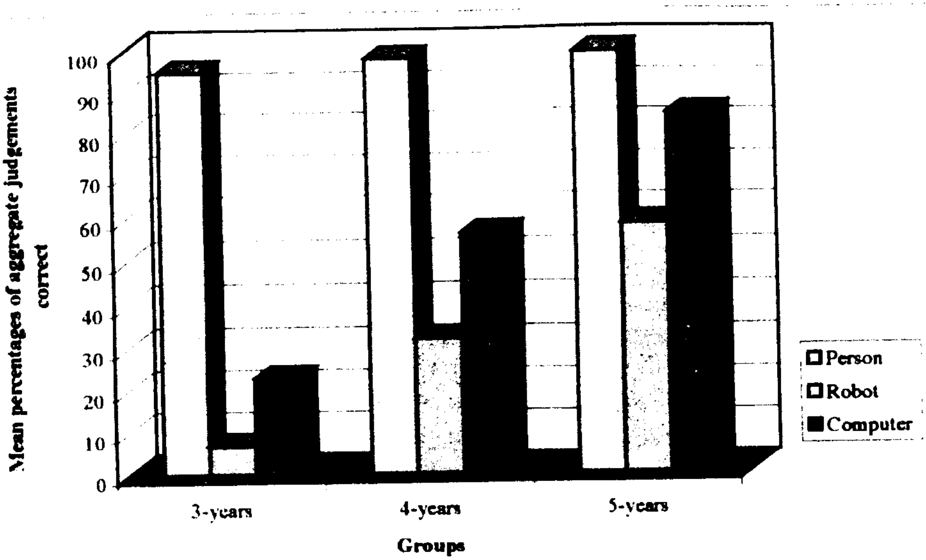


Figure 3
Mean percentages of aggregate judgements correct, classified by test item and age group.

Second, there was a main effect for age, $F(1, 51) = 15.479$, $p = .000$. Separate one-way ANOVAs examined further this finding. No significant age effect was found for the person, $F(2, 51) = .678$, *ns*. In contrast, significant were the differences between the three groups for the robot, $F(2, 51) = 8.852$, $p = 001$. Post hoc comparisons using Tukey HSD tests showed that the 3-year-old children (mean aggregate percentage correct = 7) made considerably more errors than the 5-year-olds (mean aggregate percentage correct = 58), $p = .000$. The 4-year-olds (mean aggregate percentage correct = 32) differed also significantly from the 5-year olds, $p = .044$, but not from the 3-year-olds, $p = .070$. As regards the computer, correct responses varied again considerably with age, $F(2, 51) = 15.580$, $p = .000$, Tukey HSD tests revealing that the 3-year-olds (mean aggregate percentage correct = 23) made fewer correct judgements relative to the 4-year-olds (mean aggregate percentage correct = 56), $p = .005$, and the 5-year-olds (mean aggregate percentage correct = 84), $p = .000$. The 4-year-olds also differed significantly from the 5-year-olds, $p = .011$.

To summarize, these initial analyses made it clear that children's judgements about the properties of humans are more complete and accurate compared to their judgements about the two computer artifacts. Moreover, with increasing age children display a significant shift in accuracy as regards the computer items. There was also a significant difference in correct judgements for the two artifacts, with judgements for the robot generally lagging behind in accuracy those for the computer.

Patterns of judgements on individual questions

Data were also analyzed with respect to patterns of judgements on individual questions. One reason was to see if results from individual judgements correct would support the aggregate analyses. Another was to examine whether children's incorrect judgements were due to a general uncertainty about the properties of computer objects, or due to a tendency to be animistic, that is to overextend animate properties to these artifacts. Table 2 lists the percentages of yes/no judgements for each individual question, classified by age group and by test item. Judgements that denoted uncertainty (e.g., a response "don't know" or "may be") are put into the residual category "others".

Children's responses on individual questions were compared across age groups by chi square tests. The findings for the three test items were as follows. At all ages, from 3 to 5, answers regarding the person were consistently correct (all x^2, *ns*). Most children knew that humans possess a heart and a brain, can move independently, have mental states, bodily sensations and emotions. Their views about these properties closely paralleled their consistent belief that humans are alive. $x^2(2, N = 54) = 3.213$, *ns*. The instances that children expressed uncertainty about whether the person possessed a property were rare; across age groups they did not exceed the 0.2% of responses across trials.

As for the robot, the results were quite different. First, the analyses showed a significant increase in correct judgements for 6 out of the 8 properties: brain, $x^2(4, N = 54) = 15.107$, $p = .004$; heart. $x^2(2, N = 54) = 16.722$, $p = .000$; autonomous action, $x^2(2, N = 54) = 16.722$, $p = .000$; knowledge, $x^2(2, N = 54) = 7.647$, $p = .022$; desire, $x^2(4, N = 54) = 10.765$, $p = .029$, and bodily sensation, $x^2(2, N = 54) = 11.068$, $p = .004$. The only exceptions to this age shift were responses about emotion, $x^2(2, N = 54) = 2.570$, $p = .277$, and life status, $x^2(2, N = 54) = 3.678$, $p = .159$. Here the differences in accuracy across age groups were uniformly low and failed to reach significance. Second, as Table 2 shows, children's error judgements about the robot were not due to uncertainty. Across age groups and

Table 2
Mean percentage of patterns of responses on individual questions, classified by test item and age group

	Patterns of response								
	Person			Robot			Computer		
Test questions	Yes[a]	No	Other[c]	Yes	No[b]	Other[c]	Yes	No[b]	Other[c]
	3 Years (n = 13)								
Brain	92	0	8	92	8	0	77	15	8
Heart	100	0	0	100	0	0	84	8	8
Autonomous action	92	8	0	100	0	0	38	62	0
Knowledge	92	0	8	92	8	0	69	31	0
Desire	100	0	0	92	0	8	77	8	15
Emotion	100	0	0	92	8	0	85	15	0
Pain	92	8	0	92	8	0	77	23	0
Life status	92	0	8	77	23	0	76	24	0
	4 Years (n = 25)								
Brain	96	0	4	60	36	4	56	44	0
Heart	100	0	0	60	40	0	56	44	0
Autonomous action	100	0	0	60	40	0	20	80	0
Knowledge	96	0	4	68	32	0	32	68	0
Desire	96	0	4	80	20	0	36	56	8
Emotion	96	4	0	72	28	0	56	40	4
Pain	96	0	4	52	48	0	36	64	0
Life status	100	0	0	88	12	0	52	48	0
	5 Years (n = 16)								
Brain	100	0	0	25	75	0	19	81	0
Heart	100	0	0	25	75	0	19	81	0
Autonomous action	100	0	0	25	75	0	0	100	0
Knowledge	100	0	0	44	56	0	12	88	0
Desire	94	0	6	56	44	0	12	88	0
Emotion	100	0	0	69	31	0	31	69	0
Pain	100	0	0	31	69	0	19	81	0
Life status	100	0	0	63	37	0	19	81	0

Note: [a] Correct for person. [b] Correct for robot and computer. [c] Uncertain responses.

across trials, children's uncertainty approximated 0.05%.

Developmentally more homogeneous were the results of the chi square analyses for the computer. Responses to questions about the brain, $x^2(4, N = 54) = 14.972$, $p = .005$, heart, $x^2(4, N = 54) = 17.745$, $p = .001$, autonomous action, $x^2(2, N = 54) = 7.099$, $p = .029$, knowledge, $x^2(2, N = 54) = 10.329$, $p = .006$, desire, $x^2(4, N = 54) = 18.621$, $p = .001$, and bodily sensation, $x^2(2, N = 54) = 10.487$, $p = .005$, showed a significant increase with age. Significant were also the differences between age groups in responses concerning the computer's life status, $x^2(2, N = 54) = 9.999$, $p = .007$. These results may be interpreted as evidence that with increasing age children's views become more refined relative to those about the computer. This can also be evidenced by comparing children's correct judgements for the computer with those for the robot, in Table 2. As regards uncertainty, this did not exceed the 0.2% across age groups and across trials; most errors were due to children's tendency to attribute animate properties to the computer.

In sum, the analyses of children's patterns of judgements on individual questions showed that while with increasing age children refined their animistic notion that "robots have animate properties", their tendency to attribute emotions and life to this artifact remained stable. Relative to the robot, their views about the computer were overall more accurate and their animate judgements concerning this artifact uniformly decreased with age. These findings denote a disparity in children's attributions of animate properties to the two artifacts.

Discussion

The present study examined preschool children's ability to distinguish humans from computer artifacts. The interest lied on where children aged three to five years would place a person and two computer objects along the animate/inanimate continuum, with questions concerning these items' unobservable internal properties, their ability to propel action, have mental states, experience emótions and bodily sensations, and finally their life status.

The following main findings emerged from the analyses. First, markedly different patterns of judgements emerged with respect to the two classes of objects (humans and computer artifacts). Judgements on the person (for all properties examined) were almost perfectly accurate. In contrast, the robot and the computer were regarded more ambiguously and compared to the person elicited a higher percentage of incorrect answers. These responses were not due to children's uncertainty about the nature of computer artifacts, but to a tendency to endow these objects with animate properties. The findings then support our first prediction that preschool children do not fully distinguish humans from computer artifacts. Moreover, they add to the literature (Coley, 1995; Hatano & Inagaki, 1987; Hatano, Siegler, Richards, Inagaki, Stavy, & Wax, 1993) snowing that the ability to make the animate-inanimate distinction is not fully developed in the preschool years.

Second, children at all ages seemed to treat humans in the same manner, with no significant age changes, yet they displayed a shift in the way they treated computer objects. Individual comparisons among age groups showed that children in the three- and the four-year-old groups appeared more certain that the two artifacts possess animate properties and life than did the five-year-old sample. Seen from this point of view, these results support our second hypothesis that with older age children's animistic attributions give way to a fuller awareness of the nature of computer artifacts.

How can these results be interpreted? According to Hatano and Inagaki (1995) «when children do not have enough knowledge about a target animate object, they can make an educated guess by using personification or the person analogy ...» (p. 154). That is, because they possess a rich concept of people, they use this knowledge as a source for analogically attributing properties to less familiar animate objects. Moreover, as already mentioned, computer objects represent a fuzzy case along the animate-inanimate continuum in that their ability to perform complex functions «makes them seem to approximate more and more closely the natural kinds» (Keil, 1992, p. 52).

Consequently, it seems possible that lack of exact knowledge about computer artifacts, led children in our study to a projection of properties from their knowledge of persons.

This brings us to our last finding concerning the juxtaposition of judgements elicited by the two types of computer artifacts. The analyses supported our third hypothesis showing that judgements regarding the robot were generally more animistic compared to those for the computer. Moreover, by examining each property separately another difference was evidenced. While correct responses about unobservable internal properties, mental states and bodily sensation showed a parallel increase with age, accuracies about the artifacts' ability to experience emotions and about their life status diverged. This was because even at age five children attributed robots, but not computers, these two properties.

Obviously, the cue of "cognitive" resemblance to humans cannot explain these findings, since both computers and robots are cognitively similar to humans. Thus, it is reasonable to assume that "perceptual" and "motor" similarity may be the factors responsible for this variation. While our study is insufficient to determine the relative effect of perceptual vs. motor similarity on children's animistic reasoning, some studies pinpoint that children ignore or downplay dynamic information (movement) when it competes with perceptual information about an object (Bullock, 1985; Massey & Gelman, 1988; Richards & Siegler, 1984). Bullock's (1985) findings suggest that when children are presented with familiar objects that move in unpredictable ways (e.g., a toy appearing to move by itself), even at four years, make judgements on what the object is, not how it moves. Furthermore, when five- or six-year-old children are presented with computer displays of unfamiliar moving objects and are asked to infer animacy, they focus on parts (e.g., legs vs. wheels) rather than movement alone (Massey & Gelman, 1988; Richards & Siegler, 1984). On the basis of this evidence it may be argued that the robot's perceptual similarity to humans may have influenced children more than motor similarity.

The present study has several pitfalls that may help motivate some of the research to follow. Perhaps the most important ones are: (a) the small size of the sample employed and (b) the nature of the task adopted which supplied children with a series of questions on fixed properties that should be answered in a yes/no fashion. It will be intriguing, therefore, further research to investigate the same hypotheses with a larger sample and a different type of technique (e.g., open-ended questions). A research along these lines would probably show even three year old children giving more accurate answers about the properties of computer artifacts than found in the present study.

To summarize our findings, though not conclusive in their own right, suggest that children begin to understand the inanimate nature of computer artifacts by age four or five. Until then, they see computer objects as possessing the same "stuff" of which life is made. This late acquisition is explicable from the standpoind of the domain specificity view of cognitive development (e.g., see chapters in Hirschfeld & Gelman, 1994 and in Carey & Gelman, 1991). Against the domain-general theories of development e.g., Piaget's (1929) stage theory, a growing number of researchers today agree that «conceptual change in childhood does not take place in a uniform, across-the board fashion», but instead «on a more piecemeal, domain by domain basis» (Walker, 1999, p. 203). The essential idea here is that development in specific ontological domains (e.g., humans and computer artifacts) can occur in different ways and at different rates (see also Keil, 1992), depending among other things on the kind and complexity of knowledge that need be acquired about a particular domain (Keil, 1986) and on the significance of specific concepts (Gelman, 1988; Gelman, Coley, & Gottfried, 1994). Consequently, it should not be regarded so surprising that in the present study accuracies in judgements for humans and computer artifacts varied so markedly.

Understanding the nature of computer artifacts is an important precursor to a complete understanding of the animate-inanimate distinction, but also has important ramifications to learning about information technologies. Metaphors that designers of educational software use are important for their effectiveness. The way an application environment is designed, depends, among other things, on the age and the developmental level of the users. Thus, designers need to take into account user models in order to create applications that are motivating and do not result in misunderstandings.

Many designers use anthropomorphic agents that would carry out the user's intentions and needs. However, human-human interaction is not always a good model for human-computer interaction (Shneiderman, 1992). Empirical studies have shown that there may be an advantage from clearly distinguishing human abilities from computer powers. Furthermore, guidelines for interface design maintain «don't pretend the computer is human» (Tognazzini, 1992, p. 97). Thus, the distinction between computer artifacts and humans is an important one that software designers need to take into account in using appropriate metaphors when developing educational software for preschool children.

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