Published in: Journal of Health Psychology (2003), 8, 659-670

CHILDREN'S UNDERSTANDING OF ILLNESS: THE GENERALISATION OF ILLNESS ACCORDING TO EXEMPLAR

Eithne Buchanan-Barrow, Martyn Barrett, and Mariangela Bati

Department of Psychology, University of Surrey, Guildford, Surrey, GU2 7XH, UK

Acknowledgement

This research was supported by Grant R000222514 from the Economic and Social Research Council of Great Britain

Abstract

Using children's naive theory of biology as a framework, this study examined children's illness conceptions. Children (aged 4-11), presented with one of four exemplars (child, dog, duck or rosebush) suffering an imaginary illness, were asked whether various entities from six categories, biological and non-biological, could also be afflicted. The children's illness generalisations differentiated between all of the categories; they not only distinguished between living and non-living things, but also recognised biological subkinds. Furthermore, the children's generalisations were significantly greater to the category of exemplar, indicating that human prototypicality is not the sole basis for children's generalisations. It is concluded that children's understanding of illness is mediated by a naïve biological theory which facilitates their systematic predictions of susceptibility to illness.

Keywords: children, illness, biology, naïve theory.

Eithne Buchanan-Barrow is a Research Fellow in the Department of Psychology at the University of Surrey. Her main areas of interest are: children's understanding of illness, both physical and mental; children's societal understanding, in particular children's political cognition.

Martyn Barrett is Professor of Psychology in the Department of Psychology at the University of Surrey. His main areas of interest are: children's national and ethnic identities; children's understanding of biology; children's development of language; children's drawings.

Mariangela Bati was a Research Student at the University of Surrey.

Introduction

In recent years, a growing dissatisfaction with the Piagetian approach to children's cognitive-development has led to increasing interest in the 'theory' approach. The latter approach postulates that children acquire content-specific (rather than domain-general) systems of knowledge, about which they reason using naïve theories in order to make predictions. Three particular knowledge domains have been investigated, namely physics, psychology and biology (Wellman & Gelman, 1992, 1998). According to Wellman (1990), a theory requires ontological distinctions, coherence and a causal-explanatory framework. Following Wellman's general framework, Hatano and Inagaki (1994) propose that there are three important components involved in biological thinking: 1) knowledge to ascertain the specific entities which fall within the biological domain; that is the distinction between the living and the non-living; 2) a mode of inference which permits integrated and reasonable predictions for attributes or behaviours of biological entities; and 3) a non-intentional causal explanatory framework for the behaviours relevant to biological processes.

Examination of young children's biological thinking has become the subject of intensive interest in recent years and research suggests that children do have access to a naïve theory of biology. It is apparent that children do develop an ontology of biological kinds and that they hold biologically specific causal beliefs about those ontological members, although their framework understandings about biology differ substantially from those of adults (Carey, 1985; Richards & Siegler, 1986; Springer & Keil, 1989, 1991; Springer, 1992, 1996; Wellman & Gellman, 1992, 1998; Hatano & Inagaki, 1994; Inagaki & Hatano, 1996; Keil, 1992).

Thus within a 'theory' approach, the child is portrayed as a 'theorist' (Rosser, 1994) who is capable of forming and using complex mental structures that function as explanatory systems. However, the approximate age at which such a theoretical understanding of biology emerges is yet to be clarified. Carey believes that children have a fairly limited ability to reason about biological systems until their developing knowledge, in conjunction with some structural change, results in the emergence of biological understanding around the age of 6 or 7, building on an earlier intuitive psychology (1995). On the other hand, Keil (1989, 1992) attributes much greater ability in reasoning biologically to young children, arguing that they may still hold a rudimentary understanding of biological systems, even though they lack specific knowledge of those systems. Inagaki and Hatano (1996) also believe that children acquire an autonomous domain of biology at a young age, around the age of 5-6 years, as by this age children appear to recognise commonalities across the ontological categories of humans, animals and plants.

Research has examined some of the various events, processes and categories which must form part of biological understanding. One particular aspect of children's thinking which has been the subject of sustained interest has been the children's acquisition of a biological taxonomy. Not only do children require an awareness of the living/non-living dichotomy, but also, for an integrated theory of biology, they need to expand their thinking to encompass the full range of various biological categories, such as humans, animals and plants.

According to Carey (1995), young children's understanding is based upon humans as the prototypical biological entity. She believes that young children, under the age of about 10, then extend their thinking to other biological categories according to the similarity or proximity of other entities to humans. For example, when taught on a human exemplar, children not only tend to generalise more to other ontological categories but the likelihood of such generalisations is greater the closer the links between the human exemplar and the other entities (Carey, 1995).

Children's early understanding of the biological category of human is assisted by children's inevitable involvement with issues concerning their own bodies and health (Inagaki and

Hatano, 1993). However, for a fully autonomous theory of biology, children require an understanding of the other 'living' categories, such as animals and plants, and of the commonalities between them. Research suggests that children may achieve this understanding through reference to some salient distinctive attribute or process. For example, Backscheider, Shatz and Gelman (1993) found that 4-year-olds recognise that both animals and plants can regrow if injured, while artifacts require human assistance. Inagaki and Hatano (1996) found that children as young as 5 or 6 years of age were aware of certain commonalities between animals and plants, such as the need for food/water and the ability to grow in size, and duly differentiated the animals and plants from the inanimate objects on those aspects. In fact, Inagaki and Hatano (1996) suggest that these particular properties of growth and taking food/water are essential for children's recognition of the living/non-living distinction

However, the biological status of plants appears to be more problematical than that of animals and some research has revealed children's thinking about plants to be less integrated. Slaughter, Jaakkola and Carey (1999), examining the concept of death in children aged 4-6, found that the children had a good understanding of death affecting humans and animals, but that only a minority (24%) believed that plants would die. Hatano, Siegler, Richards, Inagaki, Stavy and Wax (1993) investigated the thinking of young American, Israeli and Japanese children (5-10 year-olds) about various biological attributes and processes in humans, animals, plants and inanimate objects. The children were most accurate about humans, less accurate about animals and inanimate objects, and least accurate about plants. It would therefore appear that young children's thinking about plants may lag behind their comprehension of the animal and human categories, depending on the biological processes or attributes under examination.

Drawing upon this theoretical background, the present study aimed to explore children's understanding of illness. While most research examining children's thinking about illness has used a Piagetian framework (e.g. Bibace & Walsh, 1981; Perrin & Gerrity, 1981; Rubovits & Siegel, 1994) there have been a few studies conducted from a 'theory' perspective. These studies have found that pre-school children have well-developed theories about the ways certain kinds of illnesses are transmitted, including a cold (Siegal, 1988; Inagaki, 1997). Siegelman, Maddock, Epstein and Carpenter (1993) investigated children's understanding of the risk factors involved in catching AIDS, colds and cancer, revealing that children were generally knowledgeable about risk factors but not as competent in rejection of non-risk factors. Furthermore, some studies within a 'theory' perspective have indicated that children's acquisition of an understanding of illness across the biological domain may be problematical with reference to the plant category. Inagaki and Hatano (1996) examined 5-year-old children's generalization of illness from humans to other biological and non-biological entities and found that children were less likely to generalise to plants than to animals. Finney and Taplin (1998) looked at children's generalisations of a germ-based illness to biological and non-biological entities in children aged 5-10. They found very low attributions to plants at all ages and suggested that young children do not include all living kinds in their understanding of the transmission of germ-based illnesses.

However, all these studies which have examined children's understanding of illness using the naïve theory approach have presented the children with known diseases, thus focusing on their acquired knowledge as opposed to their conceptual reasoning about illness. An investigation of children's understanding of illness, using an hypothetical disease as opposed to a cold or other 'real' illnesses, should reveal something of their naive theory of illness.

The present study examined children's understanding of ontological categories in relation to illness, using Keil's (1989) work as a theoretical perspective. He investigated children's ontological knowledge by exploring their understanding of ontological boundaries through transformations (e.g. whether it was possible to turn a horse into a zebra, or a cactus into a porcupine). He revealed that children do have an intuitive taxonomy for structuring the biological domain and that they resist impossible biological transformations while accepting others as more plausible. Therefore, using Keil's general approach, this present study examined children's understanding of 6 ontological categories (humans, mammals, non-mammals, birds, plants and hand-made artefacts) exploring their ontological boundaries for illness by an examination of their predictions about which entities could or could not get ill.

There were three major points of difference from previous studies in this area. First, in order to test Carey's belief that children regard humans as the prototypical biological entity, the study examined children's generalisations of illness from three non-human exemplars (mammal, bird and plant) in addition to a human exemplar. The inclusion of a plant exemplar would also permit a direct examination of the status of plants as a biological category in children's thinking. Furthermore, previous studies have generally used a human exemplar, if any exemplar was used. Secondly, the children were asked about which entities could or could not get 'plinkitis', a made-up illness, in order to give them the opportunity to use their naive theories of illness. As plinkitis is not a real disease, the children were unable to draw upon any specific acquired knowledge about this particular disease, but were forced to use their naive or implicit theories of illness in order to generalise to biological and non-biological entities. Finally, in order to avoid the problems associated with open-ended interviewing of children (i.e. problems caused by children's inability to access and/or verbally express their own knowledge), the children's ontological boundaries were tested by card-sorting tasks.

It was expected that the children would indeed reveal a grasp of biological distinctions in their understanding of illness, but that they would be less likely to generalise illness to the non-biological entities, i.e. hand-made artifacts, thus revealing a comprehension of the distinction between the living and the non-living (Carey, 1985; Keil 1989; Hatano & Inagaki,1994). It was also predicted that the children's understanding of illness would be based primarily on humans and then extended to other biological categories on the basis of the similarity or proximity between the human and non-human entities (mammals, non-mammals, birds and plants) (Carey 1985). It was further proposed that the use of non-human exemplars would result in a lower degree of generalisation (Carey, 1985; Inagaki & Hatano, 1991, Hatano & Inagaki, 1999). It was also expected that the children would report lower levels of generalisation to plants than to other biological categories. Finally, it was expected that the children's responses would reveal a developing biological understanding, as children gain both in knowledge and theoretical comprehension with age. Furthermore, any such developmental differences might indicate the age at which children exhibit a naïve theory of biology, either supporting Keil's belief (1989) that very young children do display some theoretically-based thinking about biological systems or Carey's view (1995) that very young children's understanding in this area is very limited.

Method

Sample

A total of 280 children were randomly recruited from school years Reception to Year 6 (age range: 4.8-11.6 years) from schools in south-east England. The children were grouped into three age-groups for the purpose of analysis: 1) Young Group containing 120 children from school years Reception, 1 and 2 (64 girls: mean age = 6.2 years, age range = 4.8-7.7 years; 56 boys: mean age = 6.2 years, age range = 4.8-7.8 years); 2) Middle Group containing 80 children from school years 3 and 4 (35 girls: mean age = 8.8 years, age range = 7.8-9.7 years; 45 boys: mean age = 8.7 years, age range = 7.8-9.7 years); 3) Old Group containing 80 children from school years 5 and 6 (38 girls: mean age = 10.6 years , age range = 9.9-11.6 years; 42 boys: mean age = 10.8 years, age range = 9.9-11.6 years).

Materials

Thirty cards, each measuring 5 x 2.5 ins., naming five entities from each of six ontological categories, were used in each of three sorting tasks. On each card, the name of one entity was printed clearly. The ontological categories from which the entity names were drawn were (a) *human beings* (man, woman, boy, girl, baby), (b) *mammals* (elephant, cow, sheep, cat, mouse), (c) *non-mammals* (crocodile, tortoise, frog, butterfly, ant), (d) *birds* (turkey, swan, chicken, blackbird, robin), (e) *plants* (oak tree, apple tree, daisy, daffodil, sunflower), and (f) *hand-made artifacts* (house, car, bicycle, computer, cup). There were three boxes, measuring 9 x 6.5 x 7 ins., representing one of the three possible answers given by the children. Each of the three boxes was labelled with the appropriate words, which were clearly printed on the front: *can get plinkitis, cannot get plinkitis, I don't know*. Finally, four cards were used, each showing a simple black and white line drawing of one of the exemplars in reference to which children were taught about the imaginary illness. The four exemplars used were a child, a dog, a duck and a rosebush, belonging to the categories of *human beings, mammals, birds* and *plants* respectively. The exemplars were chosen from the midpoint size of each range (midpoint size of humans, mammals, birds and plants respectively) in order to minimise the effect of possible biases which might limit children's generalisations based upon the size of exemplars.

Procedure

Children were randomly assigned to either the child, dog, duck or rosebush condition. The children were all interviewed singly and were told that the purpose of the interview was to assist the interviewer in writing a book for children concerning the body. The children were assured that there were no right or wrong answers and that they should ask for clarification if they found any question difficult to understand. The three boxes with open tops without lids were put on the table. Each box represented one of the possible answers which could be given by the child: *can get plinkitis, cannot get plinkitis, I don't know*. The boxes were placed on the table in the above order for the first child and in such a way that the child could clearly see what was written on each box. For the second child the order *cannot get plinkitis, can get plinkitis, I don't know* was used. These two orders were alternated accordingly throughout the testing in order to control for possible left-right response biases. The interviewer showed the cards to the child, in a different randomised order for each individual child. The child was told that the task was to place each card into one of the boxes depending on whether he/she thought that the entity named on each card can get plinkitis, cannot get plinkitis or that he/she did not know. For the younger children, cards were read in case there were any difficulties with reading. The exact words used by the interviewer were as follows:

> *Have you ever heard of plinkitis? Plinkitis is an illness. Here is a picture of a child* (dog, duck or rosebush; depending on which exemplar the child was taught on). *Children* (dogs, ducks or rosebushes) *can get plinkitis. When children* (dogs, ducks or rosebushes) *get plinkitis they go a funny colour and they get spots. They also go very*

floppy and weak. Here are some cards with the names of lots of different things on them. What I would like you to do is put each card into one of these boxes, depending on whether you think that thing can get plinkitis or cannot get plinkitis. For example, if you think that something can get plinkitis, put the card into the box which says 'can get plinkitis' (physically hold a card over the box). *If you think that something cannot get plinkitis, put the card into the box that says 'cannot get plinkitis'* (physically hold a card over the second box). *If you really don't know whether it can get plinkitis or cannot get plinkitis, put the card in the 'don't know box'* (physically hold a card over the 'don't know box)". For the younger children the following words were added: *'if you have any difficulty reading some of the cards, tell me and I'll help you to read them.*

Results

The results are presented in the following order: (1) Children's illness generalisations: ANOVAS were conducted on the children's basic scores (the number of entities, out of five, chosen as susceptible to plinkitis) within each of the 6 ontological categories, in order to examine the children's thinking about the categories; (2) Patterns of generalisations: Configural Frequency Analysis (CFA) was conducted to explore any variations in the children's response patterns according to the exemplar on which they were taught. Additionally, log linear analyses were conducted to investigate any possible links between children's response patterns and their age or gender.

Children's Illness Generalisations

The total number of cards from within each ontological category, which were placed into each individual box, was calculated: in each case, the scores could therefore range from 0-5. The mean scores obtained by the children in each age-group were first analysed using 4-way 3 (age) x 2 (gender) x 4 (exemplar) x 6 (type of ontological category) mixed ANOVAS with independent groups on the first three factors and repeated measures on the fourth factor. These revealed numerous main and interaction effects (involving age, exemplar and category) on all three responses (can get plinkitis, cannot get plinkitis, I don't know). However, as these results were complex to interpret, the data were also analysed for each exemplar separately using four separate 3 (age) x 2 (gender) x 6 (ontological category) mixed ANOVAs, with independent groups on the first two factors and repeated measures on the third factor. These revealed main effects of type of category on all three responses (can get plinkitis, cannot get plinkitis, I don't know) with all four exemplars, suggesting that children do perceive differences between the various categories of entities when exemplars belong to different ontological categories. As the children's category inclusion responses (i.e. those entities which can get plinkitis) provide the clearest indications of their thinking, the present report will be confined to the analyses of these responses. The children's mean scores in response to the question, who can get plinkitis, are shown in Tables 1-4 and the results of the relevant ANOVA are also shown in these Tables. Scheffe tests were conducted to locate the effects involving age (see footnotes to Tables 3 and 4) and post hoc t-tests were conducted to locate the effects involving category (see Table 5).

* * INSERT TABLES 1-5 ABOUT HERE * *

Differences associated with ontological category

Child Exemplar. When the children were taught the imaginary illness (plinkitis) on the child exemplar, they claimed that humans were significantly more likely than all the other categories to get plinkitis (see Tables 1 and 5). After human beings, mammals were the most likely followed by birds, non-mammals, plants and hand-made artifacts in that order. However, the difference between birds and non-mammals was not significant. The category of hand-made artifacts was seen by all children as significantly the least likely to get plinkitis.

Dog Exemplar. When the children were taught that plinkitis is an illness afflicting dogs, they claimed that mammals were significantly more likely than all the other categories to get plinkitis (see Tables 2 and 5). After mammals they judged birds as most likely to get plinkitis, followed by humans, non-mammals, plants and hand-made artifacts in that order. It was again the category of hand-made artifacts which was seen by all children as significantly the least likely to get plinkitis. However, the differences humans and non-mammals, between humans and birds, between non-mammals and birds, and between plants and artifacts were not significant.

Duck Exemplar. When the children were taught that plinkitis is an illness afflicting ducks, they rated birds to be significantly more likely to get plinkitis than the other ontological groups (see Tables 3 and 5). After birds, mammals were the most likely to get plinkitis, followed by non-mammals, and humans, and then plants. The category of hand-made artifacts was seen by all children as significantly the least likely to get plinkitis. However, the differences between humans and mammals, between humans and non-mammals and between mammals and non-mammals were not significant.

Rosebush Exemplar. When the children were taught that plinkitis is an illness afflicting rosebushes they claimed that plants were significantly more likely than all the other categories to get plinkitis (see Tables 4 and 5). After plants they rated humans as more likely to get plinkitis followed by mammals and birds together, followed by non-mammals and hand-made artifacts. However, the differences between humans and mammals, humans and non-mammals, and humans and birds were not significant. Additionally, the differences between mammals and non-mammals, mammals and birds and non-mammals and birds were not significant.

Differences associated with age

There were no main or interaction effects involving age for both the child and dog exemplars. However, children taught on the duck and rosebush exemplars exhibited significant age x category interaction effects. Post hoc analysis revealed that the age differences for the duck exemplar occurred only in the category of birds (see Table 3), where the Young group generalized significantly less to birds than either the Middle or the Old group.

When children were taught on the rosebush exemplar, the post hoc analyses revealed that there were only significant age differences in the category of plants (see Table 4), with the Old group generalizing significantly more to plants than either the Young or Middle group.

Response patterns

In addition to the age and category differences identified in the ANOVAS, it was evident that different children presented different response patterns overall about the susceptibility to illness of entities belonging to different ontological categories and according to exemplar. In order to explore these variations, Configural Frequency Analysis (CFA) was used. This form of non-parametric, multivariate analysis of association identifies response patterns which are over-represented (types) and under-represented (anti-types) given the null hypothesis that these patterns are normally and randomly distributed (Krauth, 1985; Von Eye, 1990). Focusing on the children's choices of those entities which can get ill, the children's responses for each category were scored as follows: to those children who chose two or less entities in a category (i.e. a minority of entities) a score of 0 was given; to those children who chose three or more entities in a category (i.e. a majority of entities) a score of 1 was given. Therefore, each child had a score of 0 or 1 for each ontological category and the resulting response pattern for each participant could be characterised as a sequence of 0s and 1s, with the six categories being represented in the following order: humans, mammals, non-mammals, birds, plants and hand-made artifacts. For example, the response pattern 111000 was given to a child who chose three or more entities from the ontological categories of humans, mammals and non-mammals and two or less entities from the ontological categories of birds, plants and hand-made artifacts. The data thus generated were subjected to four CFAs, one for each of the four exemplars, child, dog, duck and rosebush. The results are displayed in Table 6, which shows there were three patterns for the child exemplar, five for the dog exemplar, seven for the duck exemplar and four for the rosebush exemplar, all of which occurred significantly more frequently than would be expected by chance.

* * INSERT TABLE 6 ABOUT HERE * *

In order to investigate any associations between the children's response patterns and age or gender, a new variable was computed corresponding to whether or not each child presented each of the significant response judgement patterns. A series of hierarchical log linear analyses was conducted to assess whether each individual response pattern was significantly associated with either age or gender. No significant associations were found.

Discussion

This study set out to examine children's understanding of illness, using their naïve theory of biology as a framework theory. Overall, the children's assessments of susceptibility to a hypothetical illness displayed an awareness of the distinctiveness of the ontological categories. Depending on the exemplar used, the children's thinking revealed discontinuities between every pair of categories in at least one condition (see Table 5).

As these differences were not age-related, this supports the view that children do possess an early grasp of biological distinctions (Keil, 1992; Inagaki & Hatano, 1996).

Furthermore, there was a paucity of any interactions with age in the study. There were minimal differences in the generalisations from the duck and rosebush exemplars, but overall, the children's differentiation of the ontological categories did not vary across the age-range tested. Furthermore, the significant response patterns identified by the CFAs were not associated with particular ages. All of these findings are further support for children's early acquisition of a naïve theory of biology (Keil, 1992; Inagaki & Hatano, 1996).

Human prototypicality

Carey (1985) proposed that humans represent the prototypical biological entity for children and that children accordingly base all their biological attributions on their assessments of proximity and/or similarity between humans and any other biological entity. In this study, the children taught on the human exemplar duly generalised most to humans, then mammals, birds, non-mammals, plants and hand-made artifacts in that order. However, other findings did not support Carey's claim of human prototypicality in young children's biological understanding.

For all three non-human exemplars, the dog, duck and rosebush, the approach was the same as for the human exemplar: the children generalised most to the category of the exemplar on which they had been taught. Carey's claim, that children will hold to the human prototype even when exposed to non-human exemplars, is based on her belief that young children have not yet acquired an understanding of the full range of biological categories. Therefore, the readiness of the children in this study to generalise as much from the non-human exemplars as from the human one, is further support for the view that children acquire an early understanding of the distinctiveness of biological categories (Keil,1992; Inagaki & Hatano,1996) .

In addition, there were no differences associated with age in the children's generalisations from the child exemplar. If young children do base their generalisations on human prototypicality to a greater extent than older children, then it would be expected that the younger children would generalise more from the child exemplar than the older children. Therefore, in the absence of any significant differences in the children's generalisations, the results do not support Carey's claim for human prototypicality.

Biological status of plants

With respect to the biological status of plants, there was mixed evidence in the children's responses. The children did generalise the illness less to hand-made artifacts than to plants, except in one condition (dog exemplar), thus supporting the view that they had acquired an understanding of the distinction between living and non-living entities (Inagaki & Hatano, 1996). Furthermore, when taught on the rosebush exemplar, they weighted their generalisations heavily in favour of the same category (i.e. plants), just as they did for all the other exemplars. On the other hand, when taught on any of the exemplars other than the rosebush, the children generalised least to plants out of the five biological categories and the level of their generalisations to plants was very low overall, suggesting that they construed plants as being very different kinds of biological entities from animals.

These differences in the way in which the children treated plants may have occurred for a number of reasons. First, the use of an unknown illness may have forced the children to resort to their core beliefs about illness, and in particular to a model of illness based on infection or contagion, which has been seen as the prototypical illness for young children (Kalish, 1999). If the children were indeed dependent on this model, then they would have been forced to consider the methods for transmission of infection between plants and other categories. Since much of their understanding of contagion depends on proximity, children may well have concluded that the opportunities for close contact with plants were more limited for both humans and animals than the possible contacts between humans and animals. Therefore, these practical considerations may have reduced the level of generalisations regardless of the children's understanding of the biological status of plants.

Secondly, children may hold specific beliefs about illnesses in plants. They may, for example, believe that illnesses affecting plants are more restrictive throughout the biological system, while those affecting humans and animals are more widespread in their scope. On the other hand, they may not have been aware that plants could get ill, unless expressly instructed by the adult researcher to the converse, as was the case with the rosebush exemplar.

Thirdly, there may have been linguistic considerations influencing the children's generalisations. Although the illness description was phrased carefully so as to be applicable to all biological categories, the children may have judged it as more appropriate to human and animal categories than to plants. In particular, the actual use of the word 'illness', though the most suitable term for both humans and animals, and one readily understood and used by the children themselves, nevertheless may have confused the issue, as plants are generally described in the English language as having a disease rather than an illness.

Fourthly, previous research has revealed that young children do include plants in their biological thinking when questioned about certain other biological processes or events, such as life status (Hatano et al., 1993), the ability to regrow after injury (Backscheider et al., 1993), the need for food/water and the ability to grow in size (Inagaki & Hatano, 1996). However, these particular biological aspects are all relatively easy to observe in plants by children, particularly by those who have the opportunity to play in gardens or parks. By the time they enter school, most young children should have had the chance to acquire the knowledge that plants are living entities, that they need water, increase in size and can repair spontaneously after injury, by simple observation. Furthermore, it is with respect to these particular biological aspects that children demonstrate an autonomous theory of biology, which they extend to plants. On the other hand, in the case of illness, as Finney and Taplin found (1998), children tend not to generalise illness to plants when asked about the effects of illness-producing germs. This may reflect the fact that, not only is illness in plants a more uncommon phenomenon than simple growth and care aspects, but illness in any biological entity, other than human, may be an unusual experience for children. Therefore, it may be that the children's responses do not necessarily indicate a less mature comprehension of the category of living entities but may be a consequence of insufficient experience or knowledge of plants.

Finally, the children's perceived discontinuity between plants and animals could simply suggest a sophisticated grasp of their differences. If this is the case, such sophisticated understanding would appear to be present at a very early age.

Conclusion

In conclusion, the children revealed a basic understanding of the distinctiveness of the different ontological categories through their generalisations of illness and, furthermore, this understanding did not appear to change substantially with age. However, human prototypicality was not the only basis for their judgements as they generalised from all the non-human exemplars most to entities within the same category. As for the status of plants, there was some evidence that the children did perceive plants as a separate biological category. However, their tendency to generalise illness least to plants out of the five biological categories would suggest that the status of plants in children's biological understanding is different from that of animals.

These findings suggest that children's understanding of illness is underpinned by an awareness of the different categories of entities which exist in the world, and that children are able to make systematic predictions about entities' susceptibility to illness based upon their knowledge of these categories from the age of 5.

References

Backscheider, A.G., Shatz, M., & Gelman, S.A. (1993). Preschoolers' ability to distinguish living kinds as a function of regrowth. *Child Development,* 64,1242-1257.

Carey, S. (1985). *Conceptual Change in Childhood.* Cambridge, MA: MIT Press.

Carey, S. (1995). On the origin of causal understanding. In S. Sperber, D. Premack, & A. J. Premack (Eds.), *Causal Cognition*, (pp. 268-302). Oxford: Clarendon Press.

Finney, D.A. & Taplin, J.E. (1998). Children's understanding of illness in living kinds. Paper presented at the 15th Biennial Meeting of the International Society for the Study of Behavioural Development, Berne, Switzerland, July 1998.

Hatano, G. & Inagaki, K. (1994). Young children's naive theory of biology. *Cognition,* 50, 171-188.

Hatano, G. & Inagaki, K. (1999). Young children's inductive projection of human properties to animals and plants. Paper presented at the Biennial Meeting of the Society for Research in Child Development, Albuquerque, April 1999.

Hatano, G., Siegler, R.S., Richards, D.D., Inagaki, K., Stavy, R. & Wax, N. (1993). The development of biological knowledge: A multi-national study. *Cognitive Development,* 8**,** 47-62

Inagaki, K. (1997). Endogenous variables mediating disease transmission. Paper presented at the Biennial Meeting of the Society for Research in Child Development, Washington D.C., USA.

Inagaki, K. & Hatano, G. (1991). Constrained person analogy in young children's biological inference. *Cognitive Development,* 67**,** 2823-2840.

Inagaki, K., & Hatano, G. (1993). Young children's understanding of the mind-body distinction. *Child Development,* vol. 64 (5), 1534-1549.

Inagaki, K. & Hatano, G. (1996). Young children's recognition of commonalities between animals and plants. *Child Development,* 67, 2823-2840.

Kalish, C.W. (1999). What young children's understanding of contamination and contagion tells us about their concepts of illness. In M.Siegal & C. Peterson (Eds.), *Children's Understanding of Biology and Health* (pp. 99-131). Cambridge: Cambridge University Press

Keil, F. C. (1989). *Concepts, Kinds and Cognititive Development.* Cambridge, MA: MIT Press.

Keil, F. C. (1992). The emergence of an autonomous biology. In M. Maratsos & M. Gunnar (Eds.), *Modularity and constraints on language and cognition* (Minnesota Symposium on Child Psychology), 25, (pp.103-137). Hillsdale, NJ: Erlbaum.

Krauth, J. (1985). Typological personality research by configural frequency analysis. *Personality and Individual Differences,* 6, 161-168.

Richards, D. D. & Siegler, R. S. (1986). Children's understandings of the attributes of life. *Journal of Experimental Child Psychology,* 42, 1-22.

Rosser, R. (1994). *Cognitive Development: Psychological and Biological Perspectives.* Boston: Allyn & Bacon.

Siegelman, C., Maddock, A., Epstein, J. & Carpenter, W. (1993). Age differences in understandings of disease causaltiy: AIDS, colds and cancer. *Child Development*, 64, 272-284.

Siegal, M. (1988). Children's knowledge of contagion and contamination as causes of illness. *Child Development,* 59, 1353-1359.

Slaughter, V. Jaakkola, R. & Carey, S. (1999). Constructing a coherent theory: children's biological understanding of life and death. In M.Siegal & C. Peterson (Eds.), *Children's Understanding of Biology and Health* (pp. 71-96). Cambridge: Cambridge University Press

Springer, K. (1992). Children's beliefs about the biological implications of kinship. *Child Development*, 63, 950-959.

Springer, K. (1996). Young children's understanding of a biological basis for parent-offspring relations. *Child Development*, 67, 2841-2856.

Springer, K. & Keil, F. (1989). On the development of biologically specific beliefs: the case of inheritance. *Child Development*, 60, 637-648.

Springer, K. & Keil, F. (1991). Early differentiation of causal mechanisms appropriate to biological and nonbiological kinds. *Child Development*, 62, 767-781.

VonEye, A. (1990). *Introduction to Configural Frequency Analysis.* Cambridge: Cambridge University Press.

Wellman, H.M. (1990). *The Child's Theory of Mind*. Cambridge, MA:MIT Press

Wellman, H. M. & Gelman, S. A. (1992). Cognitive development: Foundational theories of core domains. *Annual Review of Psychology,* 43, 337-375.

Wellman, H.M. & Gelman, S.A. (1998). Knowledge acquisition in foundational domains. In W. Damon (Ed.), *Handbook of Child Psychology,* Volume 2: Cognition, Perception and Language, (pp. 523-574). New York: Wiley.

Table 1: Child Exemplar: children's mean responses to who can get plinkitis (standard deviations in parentheses)

	Can get plinkitis			
Category	Young	Middle	Old	Total
human beings	4.57 (0.9)	4.65 (0.7)	4.20 (1.5)	4.49 (1.1)
mammals	1.70 (1.8)	2.10 (1.9)	2.75 (2.0)	2.11 (1.9)
non-mammals	1.30 (1.6)	1.00 (1.4)	1.90 (1.8)	1.39 (1.6)
birds	1.40 (1.5)	1.55 (1.8)	2.40 (2.1)	1.73 (1.8)
plants	0.47 (0.6)	1.05 (1.6)	0.35 (0.9)	0.60 (1.1)
artifacts	0.13 (0.7)	0.15 (0.4)	0.05 (0.2)	0.11 (0.5)
mean scores	1.59	1.75	1.94	1.73
ANOVA	category: $F (5, 60) = 121.68$, $p< 0.0005$			

Table 2: Dog Exemplar: children's mean responses to who can get plinkitis (standard deviations in parentheses)

	Can get plinkitis			
Category	Young	Middle	Old	Total
human beings	2.20 (2.3)	2.50 (2.5)	2.15 (2.4)	2.27 (2.3)
mammals	3.40 (1.5)	4.10 (1.1)	3.90 (1.2)	3.74 (1.3)
non-mammals	2.63 (1.7)	2.39 (1.5)	1.55 (1.6)	2.23 (1.7)
birds	2.67 (1.7)	3.00 (1.6)	2.95 (1.9)	2.87 (1.7)
plants	0.70 (0.9)	0.05 (0.2)	0.25 (1.1)	0.46 (0.9)
artifacts	0.23 (0.6)	0.00 (0.0)	0.00 (0.0)	0.10 (0.4)
mean scores	1.97	2.00	1.80	1.94
ANOVA	category: F (5, 60) = 88.39, p< 0.0005			

Table 3: Duck Exemplar: children's mean responses to who can get plinkitis (standard deviations in parentheses)

	Can get plinkitis			
Category	Young	Middle	Old	Total
human beings	2.07 (2.0)	2.65 (2.4)	2.80 (2.2)	2.44 (2.2)
mammals	2.60 (2.0)	3.15 (1.7)	2.60 (1.9)	2.76 (1.9)
non-mammals	2.57 (1.6)	2.85 (1.6)	2.35 (1.7)	2.59 (1.6)
birds	2.87 (1.8)	4.25 (1.0)	4.50 (0.7)	3.73 (1.4)
plants	0.87 (1.1)	1.10 (1.8)	0.35 (1.1)	0.79 (1.3)
artifacts	0.17 (0.5)	0.00 (0.0)	0.00 (0.0)	0.07 (0.3)
mean scores	1.85	2.33	2.10	2.06
ANOVA	category: $F(5, 60) = 99.31$, $p < 0.0005$ age x category: $F(10, 118) = 3.21$, $p < 0.01$			

Scheffe tests: significant differences between age groups

Bird category:

Young group vs Middle group ($p < 0.005$)

Young group vs Old group ($p < 0.005$)

Table 4: Rosebush Exemplar: children's mean responses to who can get plinkitis (standard deviations in parentheses)

	Can get plinkitis			
Category	Young	Middle	Old	Total
human beings	2.37 (2.3)	2.50 (2.3)	1.85 (2.3)	2.26 (2.3)
mammals	1.93 (1.8)	2.25 (2.0)	2.40 (1.9)	2.16 (1.9)
non-mammals	1.73 (1.7)	2.40 (1.9)	1.80 (1.5)	1.94 (1.7)
birds	1.77 (1.9)	2.35 (1.8)	2.55 (2.0)	2.16 (1.9)
plants	3.70 (1.5)	3.70 (1.5)	4.95 (0.2)	4.06 (1.4)
artifacts	0.13 (0.4)	0.25 (1.1)	0.05 (0.2)	0.14 (0.6)
mean scores	1.93	2.24	2.26	2.12
ANOVA	category: $F(5, 60) = 121.68$, $p < 0.0005$ age x category: $F(10, 118) = 2.57$, $p < 0.05$			

Scheffe tests: significant differences between age groups

Plant category:

Old group vs Young group ($p < 0.01$)

Old group vs Middle group ($p < 0.05$)

Table 5: Post hoc t-tests (Bonferroni corrected) to locate differences between ontological categories by exemplar for can get plinkitis

	Child (t values)	Dog (t values)	Duck (t values)	Rosebush (t values)
humans v mammals	9.41**	-4.76**	ns	ns
humans v non-mammals	12.96**	ns	ns	ns
humans v plants	20.52**	6.26**	5.68**	-5.45**
humans v birds	11.08**	ns	-4.90**	ns
humans v artifacts	26.21**	7.50**	8.68**	7.54**
mammals v non-mammals	5.28**	7.60**	ns	ns
mammals v plants	6.66**	16.02**	7.83**	-6.84**
mammals v birds	3.76**	5.65**	-3.96**	ns
mammals v artifacts	8.07**	21.24**	11.50**	9.01**
non-mammals v plants	3.90**	8.64**	8.29**	-8.07**
non-mammals v birds	ns	ns	-5.14**	ns
non-mammals v artifacts	6.22**	10.68**	12.43**	8.95**
plants v birds	5.24**	10.25**	13.37**	-6.82**
plants v artifacts	3.35**	ns	4.31**	21.14**
birds v artifacts	6.92**	12.92**	18.85**	8.63**

df = 69

$p < 0.003$** ns = non-significant

Table 6: Configural Frequency Analysis response patterns by exemplar (Bonferroni corrected)

Exemplar	Pattern	Frequency	Z score
Child	1 0 0 0 0 0	37	34.6 **
	1 1 1 1 0 0	9	7.6**
	1 1 0 1 0 0	9	7.6**
Dog	1 1 1 1 0 0	13	11.5**
	0 1 1 1 0 0	11	9.5**
	0 1 0 1 0 0	10	8.6**
	0 1 0 0 0 0	8	6.7**
	1 1 0 0 0 0	7	5.7**
Duck	1 1 1 1 0 0	12	10.5**
	0 0 0 1 0 0	10	8.6**
	0 1 1 1 0 0	7	5.7**
	0 0 0 0 0 0	7	5.7**
	1 0 0 1 0 0	5	3.8**
	1 1 1 0 0 0	5	3.8**
	1 1 1 1 1 0	5	3.8**
Rosebush	0 0 0 0 1 0	20	18.2**
	1 1 1 1 1 0	7	5.7**
	1 0 0 0 1 0	6	4.7**
	0 1 1 1 1 0	5	3.8**

$p < 0.0008^{**}$