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ABSTRACT

This study investigated the issue of whether young children understand that the acquisition of certain types of knowledge depends on the modality of sensory experience involved. Sight and touch were the two sensory modalities investigated. A total of 36 children of 3-5 years of age were exposed to pairs of objects that either looked the same and felt different or felt the same and looked different. Children's understanding of the modality-specific nature of knowledge was assessed in terms of their ability to correctly state whether they would need to see or feel the object in order to determine its identity when it was hidden under a toy tunnel. Although the 5-year-olds performed well, the 3- and 4-year-olds had great difficulty in differentiating the types of knowledge to be gained from different sensory experiences. Results are discussed in relation to children's theory of mind and understanding of the process of knowledge acquisition. (RH)

Young Children's Understanding of the Role Sensory Experiences Play in Knowledge Acquisition

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Running head: SENSORY KNOWLEDGE

Abstract

This study investigated whether young children understand that the acquisition of certain types of knowledge depends specifically on the modality of the sensory experience involved. Sight and touch were the two sensory modalities investigated. 3-, 4- and 5-year-old children were exposed to pairs of objects that either looked the same but felt different, or that felt the same and looked different. Their understanding of the modality-specific nature of knowledge was assessed by their ability to correctly state, when one of each of these objects was hidden under a toy tunnel, whether they would need to see or feel the object in order to determine its identity. Although the 5-year-olds performed well, the 3- and 4-year-olds had great difficulty differentiating the specific types of knowledge to be gained from different sensory experiences. These results are discussed in relation to children's theory of mind and children's understanding of the process of knowledge acquisition.

Young Children's Understanding of the Role Sensory Experiences Play in Knowledge Acquisition

Many researchers currently working in the area of developmental research known as children's theory of mind (Astington, Harris & Olson, 1988) regard the acquisition of the concept of representation to be the fundamental conceptual development of the preschool years between three and five (e.g. Flavell, 1988; Forguson & Gopnik, 1988; Perner, 1988). Indeed, Forguson and Gopnik (1988) have referred to this development as the acquisition of a "representational model of the mind".

A sizable number of these researchers have similar views as to the specific nature of this development. Flavell (1988) suggests that this development be viewed as cognizance, on children's part, that not only can they be epistemically related or "cognitively connected" to things in the external world in a variety of different ways, but that they are also aware of "the mental representations of the things these connections engender" (p. 246). Perner (in preparation) has stated that "an explicit understanding of representation ... is required for understanding that one and the same representation can have different interpretations" and that this understanding emerges not much before the age of 4 years. Although Wellman (in press) differs from this view in crediting 3-year-olds with some understanding of representation, he describes development between 3 and 5 as a move from a "passive repository view of mind to an active constructivist view"; the latter involves not only an understanding that mental entities such as beliefs are representational entities, but also an understanding "that beliefs are internal mental states ...directed toward a depiction of reality and hence controlling of actions." Therefore, there appears to be general

agreement that with the acquisition of the full-fledged concept of representation a child comes to understand that knowledge is not simply copied passively and directly into the mind as a result of exposure to real events in the world, but rather is constructed via the representational process.

This view, that by the age of 5 children have developed a representational understanding of the mind and of mental events such as knowledge construction, has received such widespread acceptance owing to its provision of a cogent explanation for the concurrent acquisition of many diverse metacognitive skills during the years between 3 and 5. For example, 3-year-olds do not distinguish between appearance and reality. When shown a sponge painted to look like a rock they will say either that it looks like a rock and really is a rock or that it looks like a sponge and really is a sponge (Flavell, 1986). Furthermore, 3-year-olds seem unable to attribute false beliefs to another person, that is, to appreciate representational diversity (Perner, Leekam & Wimmer, 1987). Thus when shown for example that a Smarties (candy) box is full of pencils, the child is likely to say that another child will immediately know there are pencils inside before he even opens it. Children at this age are also impaired at tasks involving representational change. If children are shown a closed Smarties box full of pencils and then the box is opened, they are likely to say that they knew there were pencils in the box when they first saw it (Gopnik & Astington, 1988).

However, 5-year-olds succeed in all these tasks. Forguson and Gopnik (1988) attribute their success to an understanding that the "real" world is represented in thought - an understanding that all these tasks require. Without this understanding, it is not possible to succeed on tasks such as these, in which it is necessary to distinguish

between representations of real things (e.g. the Smarties box full of smarties) and the real things themselves (e.g. the Smarties box full of pencils).

The acquisition of a concept of representation has also been invoked to explain the development of preschoolers' understanding of knowledge acquisition and construction. This research has focused on two levels of conceptual perspective-taking ability that Taylor (1988) derived from Flavell's ('978) distinction between Level 1 and Level 2 perceptual perspective-taking. Level 1 conceptual perspective-taking ability refers to the ability to infer what another person does or does not know (Pillow, 1989). And indeed, it appears that by the age of 3 years, or shortly thereafter, some Level 1 conceptual perspective-taking ability has developed (Pillow, 1989; Pratt & Bryant, 1988). That is, tasks that require only distinguishing between situations where knowledge acquisition could or could not have taken place, can be mastered by 3-year-olds because they need only know that knowledge is a direct result of contact between a person and appropriate events or objects in the world. An understanding of the complex, mediated and indirect character of the causal relation between the mind and the world is not required (O'Neill & Gopnik, 1989).

However, with more complex Level 2 conceptual perspective-taking tasks these young children have difficulty. Level 2 tasks require the understanding that different interpretations of the same information are possible. For example, they can require the understanding that the interpretation of information that the observer is exposed to may be influenced by psychological factors such as the possession of relevant prior knowledge: 4-year-olds often claim that a naive observer shown a small, uninformative region of a drawing will know what the drawing

depicts (Ruffman, Olson & Astington, 1989; Taylor, 1988). A Level 2 task can also involve the understanding that the same mental representation can be the result of quite different causal processes (O'Neill & Gopnik, 1989). As Gopnik and Graf (1988) and O'Neill and Gopnik (1989) have shown, older children but not younger children are adept at identifying the sources of their beliefs - that is, in saying how they came to know a piece of information. Such identification requires an understanding of how beliefs and representations are causally related to the world through perceptual and inferential processes.

Thus, to date, studies of young children's representational understanding of knowledge acquisition have been limited to Level 2 conceptual perspective-taking tasks requiring the consideration of prior knowledge or requiring the identification of the sources of knowledge. However, there remain other aspects crucial to the understanding of knowledge construction, the development of which have not yet been systematically investigated.

One such aspect is the understanding that what we learn depends on the aspect or modality in which perception occurs. For example, different information can be learnt about an object from seeing it than from only feeling it. It may be the case that this understanding is also developing during the preschool years. The impetus for this suggestion comes from a study by O'Neill and Gopnik (1989) in which children had to identify different objects just by seeing them or just by feeling them. The youngest children appeared at times not to understand that all the properties of an object cannot always be derived from isolated sensory experiences. For example, a number of the 3-year-olds, after feeling a ball hidden underneath a toy tunnel - a ball that they had never seen before - told the experimenter that they could tell

it was a blue ball. These children did not appear to understand that while they could know the ball's colour by seeing it, or by being told it, in this case it was impossible to to find out its colour just by feeling it. As this finding was, however, a gratuitous one, based on anecdotal evidence, it was not explored further in the O'Neill and Gopnik (1989) study.

The present study therefore addresses this observation more systematically by explicitly testing whether preschool children understand that the acquisition of certain types of knowledge depends specifically on the modality of the sensory experience involved. Sight and touch were chosen as the two sensory modalities to be investigated. Children's understanding was assessed in a very simple task by their ability to correctly state whether they would need to see or to feel an object in order to determine either a visual or tactile property pertaining to that object.

Method

Subjects Subjects were children attending Toronto daycare centres. Thirty-six children were tested in all, 12 three-year-olds (3:0 to 3;11, mean 3;6), 12 four-year-olds (4;0 to 4;11, mean 4;6) and 12 five-year-olds (5;1 to 5;11, mean 5;5).

Materials A red 'tunnel' (approximately 30 x 25 x 15cm) was constructed out of styrofoam. At either end the openings were covered by felt flaps. Four pairs of objects were used. Two of the four pairs of objects looked the same but felt different: (a) two identical toy felt cats, one stuffed with beans that felt hard and lumpy and one stuffed with cotton wool that felt smooth and soft (b) two identical piggybanks, one full of pennies and one empty. Both of these pairs of

objects constituted the feel condition. The two other pairs of objects felt the same but looked different: (a) two small toy footballs of the same size, shape and make, one of which was green and the other red (b) two birthday cards of the same size, shape and make, one having a striped dragon on the front and the other a spotted dragon. These two pairs of objects constituted the see condition. A little, hard, red ball and a little, yellow, soft, spongy ball wer also used in the introductory task.

Procedure

Introduction: Children were tested individually in a quiet area of the daycare. At the beginning of the task each child was given a small introduction to the task. The children were seated in front of the tunnel in front of which were placed two small picture cards of a hand and an eye. Then the children were told by the experimenter: "Sometimes we can know things by seeing them and sometimes we can know things by feeling them. In this game I'm going to ask you about things we have to see and things we have to feel. Let me show you what I mean." The experimenter then hid a little red ball under the tunnel and said: "For instance, let's lift up this tunnel and then you look inside and tell me what colour the ball is inside." After the children had responded "red", the experimenter continued: "Yes, you know it's red because you can see it's red with your eyes." At this point, the children were shown the little card with the eye on it and were told that this card means "I have to see" and they were reminded that this was one of the answers they might have to give in the game.

Following this, the experimenter hid a spongy, soft, yellow ball under the tunnel, without the children seeing it. The children were asked to put their hands inside the tunnel and to feel whether the ball

was a soft or hard ball. Once the children answered "soft", the experimenter pointed out to them that they knew it was soft and spongy because they could feel with their hands that it was a spongy, soft ball. The children were also shown the little card with the hand and told that it meant "I have to feel" and that this was also an answer they might have to give in the game. Finally, once again, the children were reminded that in this game they would have to tell the experimenter whether they would have to feel what was inside the tunnel or whether they would have to see it. In addition, as a final control check that the children remembered the two answers they would have to give, the experimenter pointed to one of the two picture cards and asked the child "What does this card mean?" The same question was then asked about the other picture card. If the children did not respond verbally to either question, the questions were rephrased as "Which card means 'I have to see/feel'" and the children were allowed to point to their answer. In both cases the order of the questions was counter-balanced across subjects.

While this introduction was elaborate, pilot studies showed it was necessary in order to ensure that the children understood that they could only feel or only see an object under the tunnel, but not do both.

Experimental Task: Following the introduction, the children were allowed to examine the first of the four pairs of objects, for example the red and green footballs. The children were shown and told that the objects were the same size and shape. They were also told, appropriately, whether they looked the same or felt the same. For example, given the footballs they were told they felt the same and they were encouraged to feel this for themselves. Then the children were told and shown how the objects were different; that is, whether they

felt or looked different. Therefore, for the footballs, they were told the two footballs were different colours, namely red and green.

Once the children had finished examining the two toys, the experimenter told the children she would now take both toys away, hide them behind her back and put only one of them back under the tunnel. Once this was done, the children were asked the test question which followed the same format for all four pairs of objects, namely, it asked the children what they would have to do to find out for sure the identity of the object underneath the tunnel.

For example, in the case of the footballs, the children were asked: "Now, to find out for sure what colour the football under the tunnel is, what would you have to do?". The children were first given a chance to respond spontaneously, verbally or by pointing to the card, with one of the two alternatives, "I have to feel" or "I have to see". If the children did not respond spontaneously, then the two alternatives were presented in a forced-choice question, for example, "Do you have to see the football or do you have to feel the football?" The forced-choice alternatives were counter-balanced across trials and subjects. This procedure was then carried out for the remaining three pairs of objects. The test questions were similar in each of these cases. For example, in the other case where seeing was required, the test question was: "Now to find out for sure which dragon is on the card under the tunnel, what would you have to do?". Similarly, for the two cases where feeling was required, the test questions were: "Now, to find out for sure which piggybank is under the tunnel, what would you have to do?" and, "Now, to find out for sure what the toy cat under the tunnel is stuffed with, what would you have to do?". [1] The order of presentation of the four pairs of objects was counter-balanced across subjects and trials.

Results

In the introductory task, all the children passed the control question concerning the meaning of the two cards. The majority of the children in each of the three age groups could answer the test questions spontaneously without needing the forced-choice alternatives to be presented.

Children's responses to the test question on each of the 4 test trials were scored as 1 (correct) or 0 (incorrect) depending on whether the appropriate action was chosen (either spontaneously or after being given the forced-choice question). As the performance of the children was almost entirely consistent on trials within each condition (see Table 1), children's scores were collapsed per condition into a pass/fail score. A score of 2/2 constituted a pass, while 1/2 or 0/2 constituted a fail. The distribution of these scores across the three age groups can be seen in Table 1.

Insert Table 1 about here

Performance increased across the three age groups. The performance of the 5-year-olds was almost perfect; they answered 91.6% of the test questions correctly. In sharp contrast to this, the 3- and 4-year-olds were only correct on 54.2% and 58.0% of the test trials respectively.

The effects of the three factors, age group, see condition and feel condition, were assessed by a loglinear analysis. This analysis revealed no significant three-way interaction between the three factors. There was also no significant age group by feel condition interaction ($p > .09$). That is, the performance of the three age groups did not differ

significantly on the trials involving feel.

However, a significant interaction between age group and see condition was found (χ^2, (2, N = 36) = 9.144, p < .02). Furthermore, a post-hoc test revealed the effect of age group on see to be a non-linear one. Fisher's Exact Test showed the difference in performance of the 3- and 4-year-olds in the see condition not to be significant (binomial p = 1.000). However, a significant difference was found comparing the performance of the 3- and 4-year-olds combined versus the 5-year-olds (binomial p = .0116). Thus, in the see condition the 3- and 4-year-olds performed significantly worse than the 5-year-olds, but not significantly differently from each other.

Post-hoc tests also confirmed that performance differed significantly on the see versus feel trials for children under 5 years of age (McNemar's binomial p = .0352). That is, the 3- and 4-year-olds did significantly better on the trials where feeling was required than on trials where seeing was required. For example, 3- and 4-year-olds were much more likely to state correctly that they had to feel the cat to find out what it was stuffed with, than they were to state that they had to see the football to find out what colour it was. In fact on 65% of the trials where children needed to see the object to find out its identity, the 3- and 4-year-olds said incorrectly that they would have to feel it. As the 5-year-olds were only incorrect on 3 trials a comparison of their performance on see versus feel was not possible.

To illustrate more clearly the difficulty that young children had with this task a typical sequence of events will be described. One 3-year-old had just told the experimenter that he needed to feel the football under the tunnel to find out what colour it was. Since it was the last trial the experimenter allowed him to go ahead and feel under

the tunnel. The child immediately put his hand under the tunnel and began to feel the football. He looked at the experimenter with a blank expression and said nothing for a few seconds. Then, emphatically, he said, "Red, I can tell it's red." He then took his hand out of the tunnel, lifted the tunnel up, and said again, even more emphatically and with a big smile, "See! it's red!". We noticed a similar hesitant silence followed by a less than hesitant guess with seven children who answered the test question incorrectly. As this was an unplanned response measure, however, not all the children had the opportunity to carry out their proposed action.

Discussion

It is clear from the above results that 3- and 4-year-old children have great difficulty differentiating the specific types of knowledge to be gained from different sensory experiences. But what accounts for this difficulty? What is the understanding that is needed to succeed on this task? And how do these results fit in with earlier findings in theory of mind and related literature? These questions will now be addressed.

It is necessary, first, to reiterate a distinction, recently emphasized by both Astington and Gopnik (in press) and Perner (in preparation) concerning two different ways of conceptualizing representation, that is, as product or as process. Knowledge states are represented in the mind; this mental activity constitutes the process of representation. However, knowledge states are also representations, in the sense that they are the products of such a process. Young children may be able to attribute such product representations to themselves and others without fully understanding how these representations came about via the representational process (Astington & Gopnik, in press).

This is the state that we believe the 3-year-olds to be in. Three-year-olds have an understanding of the mind that is mentalistic, but not fully representational. These young children understand that mental products are separate from the world, but they do not understand how these mental products are constructed. They do not, to a large extent, understand the process of representation, especially when it involves more indirect sensory experiences such as verbal communication or inferential processes (see O'Neill & Gopnik, 1989). These children are only aware of the product representations of items or events with which they or others have had direct sensory experience.

The ability of 4-year-olds to recognize different sources of knowledge in answer to "How do you know?" questions led O'Neill and Gopnik (1989) to attribute to the 4-year-olds a more or less full-fledged ability to understand the complex, mediated and indirect character of the causal relation between the mind and the world. However, the results of the present study lead us to suggest that 4-year-olds are still refining their understanding of even such direct sources of knowledge as seeing and feeling. The main impetus for this suggestion is the overwhelming failure of 4-year-olds to succeed at distinguishing the properties of objects that can only be felt or seen. Clearly, one would not want to argue that the 4-year-olds do not understand the process of knowledge acquisition at all. Our 4-year-olds, being largely of a middle-class background, would no doubt have performed well on other tasks such as the false-belief or representational change tasks which have all involved very similar populations and which do require an understanding of the representational process. However, it would appear that certain aspects of the process of knowledge acquisition, such as its modality-specific

nature, are still beyond their comprehension.

What understanding might be necessary to comprehend this modality-specific nature? We suggest that success on our task involves distinguishing between the representation of something and representing it as something. Perner (1988, in preparation) draws on Goodman's (1976) distinction between "representation of" and "representation as" to disassociate two aspects of representations: their content and their reference, and uses this distinction to explain other theory of mind tasks such as the false-belief task and the appearance-reality distinction. With respect to this distinction, children who succeed in the latest task understand that although seeing may for instance, result in a representation of a ball, seeing is also the source of their representation of the ball as a blue ball. Similarly, they understand that should this blue ball also be spongy, then in the absence of perceptual experience, feeling would also result in a representation of a ball, and in addition feeling would be the source of their representation of the ball as spongy.

Another way of expressing this understanding is to say that this task requires not only an appreciation of the many different causal processes that can lead to one and the same product representation; that is, a representation of the object's identity, but also an understanding of how that identity was constructed out of its component properties and characteristics that are represented separately by all the different sensory experiences that occurred between the object and the person. More briefly, the children must understand the specific aspects of knowledge, such as texture and colour, that are the product of individual sensory experiences, such as feeling and seeing.

Moreover, the tendency among young children appears to be to

overestimate the effects of certain sensory experiences. Indications of this already exist in the literature. As mentioned previously, Ruffman, Olson & Astington (1989) and Taylor (1988) found that children below the age of 6 mistakenly attributed knowledge of what a drawing represented to a person who had seen only an uninformative part of the drawing. In addition, in the literature of egocentrism, Mossler, Marvin and Greenberg (1976) used a privileged information situation to investigate young children's ability to engage in conceptual perspective taking. The children were exposed to both the audio and visual portions of a videotaped story and were then asked about their mother's knowledge of both portions, after she had received only the visual portion. Mossler et al. found that of the 3-, 4- and 5-year-olds, 95%, 40% and 15% respectively overattributed knowledge to their mothers. These results could be interpreted as a failure on the part of these children to understand the consequences that receiving information from only one modality has on knowledge acquisition.

In our study, there was a marked tendency for the 3- and 4-year-olds to overestimate the effects of tactile experiences. The most common error was to answer "I have to feel it" when asked to determine a visual property of the object. We suggest two reasons for the frequency of this error. First, if children possess no understanding of, or very little understanding of the representational process, then seeing is probably harder to identify as an action they can choose to do than feeling is. Indeed, Flavell and his colleagues (Flavell, Green & Flavell, 1989) have argued just this point. They emphasized that as tactile experiences are perceived of as occurring externally of one's head region, one "...can observe and reflect on the whole epistemic event and can easily distinguish among its three components - the

object, the subordinate experiencer [i.e., the sensing hand], and the latter's experience of the object" (p. 202). However, as visual experiences are perceived as taking place in the head region, one cannot, as Flavell et al. point out, observe and reflect on one's own visual experiences in the same way and differentiating between the three components is considerably more difficult.

Secondly, in children's everyday experience feeling usually provides a much more direct and detailed experience of the nature of an object than just seeing it does. We suspect that it is probably not wrong to say that most children, seeing a new attractive toy for the first time, would not be content just to see the object, but rather would want to hold it and examine it for themselves. If this is the case, then even though children in our task understand that they can only feel and not see the object, unless they possess an understanding of the representational products of individual sensory experiences, they may not realize the effects that being limited to one sensory modality will have on the resulting product representation.

Finally, the results of this study may be of relevance to young children's aesthetic activity. The understanding of the representational products of individual sensory experiences may be an example of what Piaget referred to as figurative modes of cognition. It is precisely these modes of cognition that "... are central to artistic activity: the ability to perceive details within a sensory modality..." (Gardner, 1977, p.93). Thus, an appreciation and understanding of artforms may not be possible until at least the age of five or six years at which time the child has developed an understanding of the representational products of the individual sensory systems.

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Table 1

Distribution of Scores per Age Group and per Condition

Age Group	3		4		5	
Condition	See	Feel	See	Feel	See	Feel
Score						
0	7	2	8	2	1	0
1	1	3	0	0	1	1
2	4	7	4	10	10	11

Footnotes

[1]Where possible, the test question included mention of the superordinate distinguishing visual or tactile property (i.e., colour, stuffing), without mention of the categorical instances of the properties themselves (e.g., red, soft). However, in 2 cases this was not possible (i.e., weight, pattern) as the questions became too difficult for the children (e.g., What is the weight of the piggybank under the tunnel?). Therefore, in these two cases the children were asked "..which piggybank/dragon..." However, since the two objects on each trial differed only with respect to a visual or tactile property, asking the children what they had to do to find out "which x" or "what the property of x" was under the tunnel was equivalent in both cases to asking what they had to do to find out x's identity.