Development of understanding of the causal connection between perceptual access and knowledge state

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1. Introduction

When an infant shows familiarity with faces or places, adult observers assume she must have had previous experience of them. That is, as adults we assume a causal connection between perceptual access and knowledge state. Yet we do not impute the infant with understanding of that causal connection. Rather, we assume that she cannot help but gain knowledge as a result of her perceptual experiences, without realising that she is so doing, and without understanding how she is so doing. At some point in development, we assume, she will come to realise and understand. When? How? Answering even the first question is not easy, and most of the research summarised in this chapter focuses on that, aiming to identify the course of development. We know virtually nothing about ‘how’ – what underlying processes lead to advances in understanding - but the chapter finishes with brief speculation about how we might begin to find out.

One difficulty associated with answering the question ‘when?’ is deciding what the child must do for the observing researcher to impute understanding of the causal connection between perceptual access and knowledge state. There have been two broad approaches to this. With the first approach, the child is expected to reflect upon the knowing process and, usually, make an oral report. For example, children are asked
whether somebody who has seen or not seen inside a box, knows what it contains; are
asked whether they need to see of feel a hidden toy to identify its colour or hardness; or
are asked how they found out about the toy’s properties having just seen or felt it. These
studies follow the classic approach taken in research into children’s developing
understanding about the mind, in which the child usually makes her understanding
verbally explicit (e.g. research presented in Astington, Harris & Olson, 1988). The next
section of this chapter reports work that follows this approach.

The second broad approach, summarized in the third section of this chapter,
examines children’s patterns of knowledge-gaining behaviour. For example, researchers
examine whether children’s pattern of behaviour is consistent with treating a well-
informed person as more knowledgeable than a poorly informed one. Similarly, we can
find out whether children spontaneously access the informative modality (e.g. seeing or
feeling) in order to identify an object’s properties. We can find out whether they behave
as if they realise that their knowledge derived from a particular source (e.g. seeing or
feeling the object, or being told by someone). The child’s understanding is implicit in her
pattern of behaviour, but she is not required to make it verbally explicit.

The two broad approaches differ in the balance of reflection demanded from the
child and from the observing researcher. With the first approach, the child is expected to
reveal more or less directly what she understands by verbalising it. Suppose a child gains
knowledge by seeing or feeling an object and is then asked “How do you know it’s the
red cat?” or “How do you know it’s the soft bear?” If she answers “Because I saw it” in
the first case but not the second, then it takes rather little interpretive work on the part of
the observing researcher to conclude that the child understands about seeing as a source
of her knowledge. In contrast, with the second approach, the child’s task is merely to gain
knowledge, for example to find out whether a cat hidden inside a box is red or blue.
Suppose she looks rather than feels, but feels rather than looks when the hidden bear is hard or soft. The child may not reflect on the knowing process at all, but the observing researcher can infer from the pattern of behaviour that the child understands, at least on some level, what knowledge can be gained from a particular modality of access.

It is of interest to consider to what extent conclusions drawn from these contrasting empirical approaches are consistent with each other, and what the implications are if they are inconsistent. It could be, for example, that children show the pattern of finding out behaviour consistent with understanding a particular aspect of the process of gaining knowledge from perceptual experience, only when they can also reflect and report on it explicitly. Another possibility is that finding out behaviour seems to be in advance of reflective, explicit understanding, and if so this would raise the question of what is to be gained by achieving the latter. Finally, should it turn out that children could report explicitly on an aspect of the knowing process, without equivalent understanding being evident in their finding out behaviour, then the researcher might suspect that something was amiss with one or other of the assessments.

Each of the next two sections in the chapter is broken into three matching subsections, dealing with ‘Evaluating other people’s knowledge on the basis of their perceptual access’, ‘Knowing how to gain knowledge oneself’, and ‘Knowing how knowledge was gained.’ Both the reflective and the behavioural approaches have examined children’s understanding of each of these aspects of understanding about the knowing process. The research summarised in this chapter focuses on children aged between around three and five years, since both approaches reveal interesting developments in understanding about the process of gaining knowledge that occur over this age range.

2. **Children’s reflections on the knowing process**
2.1 Evaluating other people’s knowledge on the basis of their perceptual access

What reflective understanding of the knowing process seems already to be in place amongst three-year-olds? Several studies suggest children this young are not completely unaware of the relationship between perceptual access and knowledge state. For example in Pillow’s (1989) study, one of a set of differently coloured dinosaurs was hidden in a box. The child watched two puppets, one of whom looked inside a box and the other of whom pushed the closed box (so that both puppets had interacted with the box in some way). Children were asked “Who can tell you what colour the dinosaur is?” Note that in this study children did not need to understand the meaning of ‘know’ to answer this question correctly. Each child played this game several times. Both three- and four-year-olds performed well, being much more likely to attribute knowledge to the puppet who had seen than to the one who had not. The conclusion was that they “understood perceptual exposure to the external world as a determinant of mental states…” (p125). A similar conclusion arises from other studies in which the word ‘know’ was used in the test question. Note however that children might just associate knowing with seeing, without necessarily interpreting the relationship as causal. Several authors have argued that young children make the crude association ‘seeing = knowing’ (e.g. Perner, 1991).

Incidentally, puppets or dolls are commonly used in this research. The reason is that puppets and dolls are easier to manage than having children in pairs, cheaper and more convenient than using two adult experimenters, and importantly, are less likely to over-awe the young child. Yet this seems to add an unwanted layer of complexity since the child has to treat the dolls as if they gain knowledge in the same way as real people. However, although the occasional five-year-olds makes comments such as “It’s only a puppet, it can’t see anything,” younger children’s judgments appear to be no less accurate.
with these procedures, and so most researchers generally assume that they do not produce misleading results.

At around three years of age, then, children may make at least a gross distinction between epistemic and non-epistemic access (Pillow, 1993). They still have a good deal to learn, however, before we can impute to them adult-like understanding of the causal connection between perceptual access and knowledge state. One limitation is that three-year-olds, as well as four-year-olds, tend to over-estimate the knowledge to be gained from limited perceptual access. In the dinosaur experiment described above, looking inside the box was sufficient to find out the dinosaur’s colour, and pushing the box provided no knowledge of its content. But suppose, instead of finding out the dinosaur’s colour, the puppet was trying to find out whether it was the large or the small brontosaurus in the box, and the puppet only peeped through a tiny window that provided insufficient information. The evidence suggests that children would have still attributed knowledge to the puppet who looked, wrongly in this case (Robinson & Robinson, 1982; Robinson, Thomas, Parton & Nye, 1997; Taylor, 1988).

Furthermore, three- and four-year-olds cannot yet judge what knowledge is gained from different kinds of perceptual access such as seeing, feeling, smelling or tasting (O’Neill, Astington & Flavell, 1992; Pillow, 1993). For example, in one of O’Neill et al.’s studies, children watched two puppets, one of whom saw a hidden toy, and the other of whom felt it. On each trial, only one modality of access was informative, since the hidden toy was identified by color or hardness. Children were asked which puppet was knowledgeable, for example “Who knows the pig inside is squishy?” Children aged three, four and even five years were biased to judge that the puppet who had seen the toy was knowledgeable. Although the older children performed better than the younger ones, even the five-year-olds made errors.
Summary: Many three-year-olds’ explicit judgements about others’ knowledge are consistent with their differentiating epistemic from non-epistemic access (whether or not the word ‘know’ is used), but three- and four-year olds commonly make errors when judging what knowledge others gain from particular modalities of access such as seeing or feeling an object. These children may simply associate seeing with knowing.

2.2 Knowing how to gain knowledge oneself

This difficulty understanding what kind of knowledge is gained from particular modalities was apparent in another of O’Neill et al.’s (1992) studies in which children made predictions about what knowledge they themselves would gain by seeing or feeling a toy hidden inside a tunnel. Children could either raise a curtain to look inside, or put their arm in to feel the hidden toy. The hidden toy was identified by colour or hardness. Children were asked, for example “To find out for sure what colour the football inside the tunnel is, what would you have to do?” In response, children selected a card depicting an eye or a card depicting a hand, to indicate whether they would need to see or feel the toy. Many three- and four-year-olds chose the same mode of access on every occasion, whereas five-year-olds performed well. Difficulties remain when three- and four-year-olds do not have to predict the informative modality of access, but merely have to re-enact what they have just done (under the Experimenter’s guidance) to identify, for example, whether water was warm or cold (O’Neill & Chong, 2001). In this study, the Experimenter showed children how find out a certain property, for example to smell a bubble bath to find out whether it was strawberry or lemon. Then children were asked ‘Show me how you found out…?’ All they had to do was repeat the action they had just performed, yet 3-year-olds were correct only 60% of the time.

Summary: When asked how to find out an object’s properties, three- and four-year-olds again reveal limits in their understanding of what knowledge can be gained
from particular modalities of access. They seem not yet to construe knowledge as arising from, or caused by, particular kinds of perceptual experience. It remains unclear whether children make a causal interpretation but remain ignorant of the details of what knowledge arises from particular experiences (and so make errors in their specific predictions), or whether they see no causal connection between experience and knowledge state.

2.3 Knowing how one’s knowledge was gained

Perhaps the most obvious way to find out if someone understands the causal connection between having seen inside a box and knowing its content is to ask them directly, and this is what many researchers have done with young children. In a typical task, a novel object is hidden inside a container, and the child is invited to have look or have a feel to identify it. Immediately after, she is asked “What is it?” and “How do you know?” Each child plays the game several times with different target objects. Most five-year-olds can answer both questions correctly, but some four-year-olds and many three-year-olds are correct on the first question only: They can report what they know (“There’s an elephant in the box”), but not how they know it (“Because I saw it”).

When asked “How do you know there’s an elephant in there?” the answer “Because I saw it” might convince us that causal understanding is in place. On the other hand, failure to give that answer is not necessarily sufficient grounds for concluding absence of causal understanding. Even adults sometimes make errors about how their knowledge was gained (e.g. Johnson, Hashtroudi & Lindsay, 1993). For example, on feeling familiar with the content of a particular book, I might believe I have read it, whereas in fact I only read a review. Mistakes such as these are interpreted as performance errors. With adults, they generally occur when there is considerable delay between experience and recall, or when there has been an intervening event such as
misleading questioning (“You had the book at the airport, didn’t you?”) Children, with their less secure grasp of the knowing process, may be particularly prone to such errors, and might make them even with short delays between experience and recall. The conditions under which children make such errors, and how to minimise the risks of their occurring, are examined in the literatures on suggestibility and eye witness testimony (e.g. Roberts & Blades, 2000).

How then can we be sure when children’s errors answering “How do you know?” arise from failures to understand how they gained knowledge, rather than just being performance errors? Researchers try to make the child’s task as simple as possible, and to ask the child to report her source immediately after she has gained the knowledge. If children repeatedly make errors answering “How do you know?” under these conditions, then it seems unlikely that they are just making the kinds of performance errors described above. On the other hand, they might misunderstand the question. In an attempt to deal with this, Gopnik & Graf (1988), and O’Neill & Gopnik (1991) gave children in their sample a short training session before the experiment proper began, with the aim of drawing children’s attention to the source of their knowledge and clarifying the intended meaning of the test question. On the training trials, children experienced seeing or feeling an object, and were asked for example “What did you see?” followed by “How do you know that’s what’s inside?” They were then told what the correct answer was. One or two practices of this kind would not be sufficient to teach the child something she did not already understand, but could serve to clarify the purpose of the Experimenter’s questions. This may be particularly important given the social peculiarity of showing a child a picture, for example, and then asking “How do you know…?” Perhaps by four years, with nursery experience, children have become more used to the idea that adults test them in strange ways. Although training led to no significant improvement in the
accuracy of children’s answers on subsequent trials (Gopnik & Graf, 1988), some kind of training has commonly been included in subsequent research as a precaution. Checks are also made on failure to understand what behaviours “seeing” and “feeling” refer to (e.g. Gopnik & Graf, 1988; O’Neill & Gopnik, 1991; Wimmer, Hogrefe & Perner 1988).

Another way of ensuring children understand the intended meaning of the question “How do you know?” is to offer alternative answers such as “Is it because you saw it, or because you felt it?” but even with such prompts, three-year-olds typically perform poorly. Yet children who fail to answer correctly how they know, can nevertheless report what their perceptual experience was. Haigh & Robinson (2008) gave children two modes of access to the identity of a hidden toy, one of which was informative (for example seeing a toy identified by colour) and the other of which was uninformative (for example being told the toy’s colour by the Experimenter who had only felt it). Children were able to report accurately who saw and who felt the hidden toy, without necessarily being able to report how they knew its identity. That is, children apparently failed to make the causal connection between perceptual access and knowledge state, despite being able to report both what they knew (the hidden toy’s identity) and what their access had been (for example, that they had seen it).

Children’s failure to report how they gained knowledge leads to the conclusion that around three years of age they “…do not seem to be able to understand how their beliefs…are causally related to the world itself through perceptual…. processes.” (Gopnik & Graf, 1988, p1370). Wimmer, Hogrefe & Perner (1988) conclude similarly that “most three- and some four-year-olds seemed completely ignorant about the causal connection between access to an informational source and resulting knowledge.” (p386).

Summary: The most direct way of finding out whether children understand the causal connection between perceptual access and knowledge state is to ask “How do you
know?” immediately after they have acquired knowledge. Even with precautions in place to minimise the risk of children misunderstanding the question in some way, three- and four-year-olds often cannot report how they know (for example “I know because I felt it”). Despite being unable to report how they know, children may report accurately what their perceptual experience was (for example, that they felt the toy), and also, of course, what the content of their knowledge is (for example, the soft bear). This pinpoints children’s problem: They seem to fail to make a causal connection between perceptual experience and knowledge state.

2.4 Conclusions from the work on explicit, reflective understanding

By around five or six years of age, children can demonstrate adult-like understanding of the connection between perceptual access and knowledge state, although errors are still made in particular cases. In contrast, three- and four-year-olds are often poor at reporting what another person knows on the basis of their particular experience, poor at predicting what perceptual experience would lead them to gain particular knowledge, and poor at reporting the source of knowledge they have only just gained. The broad conclusion on the basis of the evidence summarised so far, then, is that many three- and four-year-olds have quite severe limitations in their understanding of the process of acquiring knowledge as a result of perceptual experiences.

It is important to bear in mind that these ages provide only a very rough estimate of when children come to understand the causal connection between perceptual experience and knowledge state. In some tasks, some four-year-olds and even some three-year-olds, answer correctly. Some five-year-olds make errors. None of the tasks described in the preceding (or following) sections have been given to large, representative samples of children of different ages in the way that reading tests, for example, are standardised. Researchers aim not to identify a particular age at which we
can say children achieve causal understanding, but rather to identify the developmental course and how it relates to other aspects of development.

During the early years when children apparently lack explicit understanding of the knowing process, children have of course been gaining knowledge as a result of their perceptual experiences. The next section reports studies that examine how they go about gaining such knowledge, and discusses what this in turn tells us about children’s understanding of the causal connection between perceptual access and knowledge state.

3. Children’s Finding Out Behaviour

3.1 Behaviour consistent with evaluating other people’s knowledge on the basis of their perceptual access.

Suppose you observe somebody looking inside a coffee jar, who then tells you it contains teabags. You are likely to believe this informant because he appears to have had access to the necessary information. You are less likely to believe a second person who now enters the room and announces, without looking inside, that the coffee jar contains sugar. This pattern of belief and disbelief of what we are told, based on the informant’s access to information, relies on understanding the connection between perceptual access and knowledge state, and so offers a way of assessing children’s understanding. A child who shows the predicted pattern of belief and disbelief, behaves in a manner consistent with such understanding.

On the other hand, failure to show the predicted pattern might not indicate failure to understand the relation between perceptual access and knowledge state. The child might understand the causal connection between experience and consequent internal knowledge state, but fail to understand the connection between internal knowledge state and consequent output (in this case, what the person says).
In addition, other factors might influence children’s readiness to believe what they are told, such as the status of the informant, presence of cues that the person is joking or teasing, or knowledge of the person’s past history of reliability (Harris, 2007; Koenig & Harris, 2005; Nurmsoo & Robinson, 2008a; 2008b; Robinson & Nurmsoo, 2008). Hence a child who fully understands the causal connection between input, knowledge state and output might nevertheless disbelieve what she is told for other reasons. As highlighted in section 2.3, negative results might be hard to interpret in terms of absence of causal understanding, although positive results provide evidence of such understanding.

To find out whether children behave as if they take into account another person’s perceptual access when deciding whether or not to believe what they say, Robinson, Champion and Mitchell (1999) devised a game in which children aimed to identify the content of a container. Three- and four- year-olds were shown that two identical dustbins contained different toys: One contained a teddy bear and the other a toy snowman. The two dustbins were mixed up and one was chosen. Was it the one with the teddy bear, or the one with the snowman? A monkey puppet operated by the Experimenter asked the child what she thought, and the child made a guess, for example “Snowman”. Next, the monkey asked the Experimenter what she thought, and the Experimenter always contradicted what the child had said, for example, “Teddy” Crucially, on half the trials the child observed that Experimenter had looked inside the dustbin before answering, and on the other half she, like the child, simply guessed. Finally, Monkey, puzzled by the contradictory suggestions, asked the child again “So which one is it, the snowman or the teddy?” If children understood the likely truth of the Experimenter’s suggestion when she had seen inside, and its unreliability when she had not, then as a group they should repeat the Experimenter’s suggestion more frequently when the Experimenter had seen than when she had not. This is the pattern of results obtained. The conclusion was that
children as a group understood the connection between perceptual access and knowledge state, and took that into account when deciding whether or not to believe what they were told.

In contrast, when the children were asked to make an explicit knowledge judgment such as “Who knows best what’s inside?” they performed much more poorly. Although their readiness to believe what the Experimenter told them was influenced by the Experimenter’s access to relevant information, children often seemed not to be able to reflect on knowledge states directly. Children this age are familiar with the word ‘know’, but they do not yet apply the word in an adult-like manner.

The fine details of the procedure used in games such as this are crucial. For example, it is important that a poorly informed adult does not appear to be untrustworthy due to the mere fact that she offers a suggestion about the content of a container she has not looked inside. By having Monkey ask each player “What do you think it is?” the Experimenter can reply with a guess such as “Snowman” without seeming to be irresponsible, but equally can reply in the same way when she has seen inside the dustbin without implying uncertainty.

In the experiment just described, the child had only to differentiate occasions when the Experimenter was fully informed, having seen inside the dustbin, from occasions when she was completely ignorant, having not seen inside. In subsequent experiments the child listener’s task was made more difficult (Haigh & Robinson, 2008; Whitcombe & Robinson, 2000; Robinson & Whitcombe, 2003): on trials when the Experimenter was only guessing, she took uninformative access to the target toy, such as feeling it to find out its colour. This variant of the game used pairs of toys that either looked the same but felt different, one hard and one soft, or felt the same but differed in colour, for example one red and one blue. One toy from a pair was placed in a box in
secret, and the child’s task was to identify it. On each trial, both child and Experimenter made a suggestion as to which toy was in the box, with the child having a second (final) opportunity to say what she thought having heard the Experimenter’s suggestion. For example, on some trials the child was invited to feel a hidden toy identified by colour, said which one she thought it was (for example, “Red cat”), then the Experimenter had a look, contradicted the child (“Blue cat”), and the child made a final judgment which was then checked by taking the toy out of the box. On other trials it was the Experimenter who had uninformative access, and the child who then had informative access. On yet other trials, both child and Experimenter had the same uninformative access.

As in the dustbin task described above, the pattern of results suggested that three- and four-year-olds understood when the Experimenter was better informed than they were: Children were much more inclined to change their mind and make a final judgment consistent with the Experimenter’s suggestion when the Experimenter was the one who had informative access, for example having seen a toy identified by colour. When both child and Experimenter had the same uninformative access, for example when both felt a toy identified by colour, children were much less likely to make a final suggestion consistent with the Experimenter’s. And when the child had informative access (for example, she saw the red cat) and the Experimenter only felt it, children more rarely gave a final judgment in line with the Experimenter’s suggestion.

The conclusion is that as a group, children aged three to four years, as well as four- to five-year-olds, revealed that they understood the causal connection between the Experimenter’s access to information and the likely truth of her suggestion.

Yet when these children were asked, for example, “How do you know it’s the red bug, because you saw it or because I said so?” the three- to four-year-olds performed no
better than they would if they were guessing the answer to that question (Robinson & Whitcombe, 2003).

An obvious interpretation of these results is that children’s decisions to believe or ignore the Experimenter drew on implicit or working understanding about the knowing process, whereas to answer “How do you know...?” children needed to have achieved explicit, reflective understanding. By differentiating different levels of understanding that are more or less explicit, we can allow children to understand at a lower, more implicit, level but not at a higher, more explicit level (e.g. Dienes & Perner, 1999; Karmiloff-Smith, 1992). This approach, and problems with it (in this context) are discussed further in section 4.

**Summary:** Three- and four-year-olds’ tendency to believe what they are told by the Experimenter when she is well-informed, but to disregard what they are told by the Experimenter when she is ignorant, suggests that on some level they do understand the causal connection between perceptual access and knowledge state, even if their verbally explicit comments do not yet reveal such understanding. It is important to note that what is identified in this research is a pattern of behaviour within groups of children: the results show that children are more likely as a group to believe what the Experimenter tells them when she is well-informed rather than poorly informed. It is not the case that every individual child shows this pattern. In any case, individual children’s responses cannot be interpreted. Whereas an individual child’s responses to the explicit questions described in sections 2.1 to 2.3 are either correct or incorrect, this is not the case with the behavioural measures used in this section. It is not wrong to follow the Experimenter’s guess on any particular trial, although in general we would expect to find that someone who understands how knowledge is gained will be more likely to believe the Experimenter when she is well-informed.
3.2 Behaviour consistent with knowing how your knowledge was gained.

In section 3.1, children’s decisions to believe or ignore the Experimenter’s suggestion about the hidden toy provided a behavioural parallel to the explicit question used in section 2.1: “Does the Experimenter know what’s in the box?” We can take the finding out game a step further to examine a behavioural parallel to “How do you know?” If the child believed what the Experimenter told her because she thought the Experimenter was well informed, but then it turns out that the Experimenter might not have been well informed after all, then the knowledge gained from the Experimenter might not be reliable. Haigh and Robinson (2008) and Robinson, Haigh and Nurmsoo (2008) examined whether children realised the implications of their informant’s expressed doubt about the adequacy of his information access to the target toy. The game was a modification of the one described above: the Experimenter had either informative or uninformative access to the target toy, said which toy she thought it was, then the child had uninformative or informative access and said which toy she thought it was, appropriately relying on the Experimenter’s suggestion more frequently when the Experimenter was the better informed. There was a further stage just after the child had said which toy she thought it was: the Experimenter then said “I’m not sure I felt it properly that time. Could it be the other one?” Children simply answered “Yes” or “No.” If the child’s judgment had been based on the suggestion made by the apparently well-informed Experimenter (for example if she had felt a toy that was hard or soft, and the child had only seen it), then the correct answer was “Yes” (it could be the other one, because the child was reliant on the Experimenter’s feeling). On the other hand, if the child’s final judgment was based on her own informative access (for example if she had seen a toy identified by colour but the Experimenter had only felt it), then the correct answer was “No” (it couldn’t be the other one, and it’s completely irrelevant whether or
not the Experimenter felt properly). This pattern was indeed found amongst children aged between three and five years.

It could, however, be over-interpreting to treat this as evidence that children realised the implications of the Experimenter’s doubt about his perceptual access. Various further checks are needed. Perhaps children are simply less confident in knowledge gained indirectly from what somebody tells them, than in knowledge gained by their own direct access (in this case, seeing the toy’s colour or feeling its hardness). If so, then any expression of uncertainty from the informant (the Experimenter in this case) might be sufficient to make them accept “It could be the other one”, without any suggestion that the Experimenter’s access to relevant information was in doubt. Checks on this showed that general lack of confidence in knowledge gained indirectly from another person, compared with knowledge gained directly, was not sufficient to explain the results. Children did indeed appear to understand the specific implications of the Experimenters’ doubt about the reliability of her access to the hidden toy.

As in section 3.1, it is of interest to examine the relationship between the understanding revealed by children’s responses to the Experimenter’s doubt about this access, and their ability to report explicitly how they gained their knowledge. Robinson, Haigh & Nurmsoo (2008), instead of asking children “How do you know…?”, used an explicit source question that was better matched to the doubt question (which was “Could it be the other one, yes or no?”), so that in both cases the correct answer was either “Yes” or “No”. The new source reporting question was, for example “So, you found out it was the hard one. Did you find out it was the hard one because I told you, yes or no?” (Importantly, sometimes the correct answer was “Yes” and sometimes “No”, so children who were biased always to say “Yes” were not mis-diagnosed as understanding about their knowledge sources.) There was a significant relationship between children’s
answers to these two questions, suggesting that as children came to realise the implications of the Experimenter’s doubt about his access, they also became more aware of how they had found out the toy’s identity. In addition, there was weak evidence that some children who failed the explicit source question, nevertheless realised the implications of the Experimenter’s doubt about his access (thereby behaving as if they understood implicitly that he was the source of their knowledge). That is, there was an indication, but not strong evidence, that children’s finding out behaviour was in advance of their ability to reflect on and report explicitly how they got to know.

**Summary:** Children aged three to five years who appropriately believed what the apparently well-informed Experimenter told them, appropriately revised their belief in the light of doubts about the Experimenter’s perceptual access. This implies that on some level they understood the source of their knowledge. Children may reveal source understanding in this way without yet being able to report explicitly how they knew, although further research is needed to check on whether that is the case.

### 3.3 Behaviour consistent with knowing how to gain knowledge.

The final set of experiments to be reported was the behavioural equivalent of the work reported in section 2.3, in which children reported how they would gain knowledge of a hidden object’s properties. In the studies below, children were simply asked to identify the hidden object by its colour or shape, and the researchers observed how they set about it: did they spontaneously take the informative modality of access? Full details of the experiments appear in Robinson, Haigh & Pendle (2008).

In the first experiment we tested three- and four-year-olds. Half the children had the task of identifying which one of a pair of toys the Experimenter had placed on the table in front of them. For some pairs, both toys felt the same but differed in colour, for example a red and a blue cat. For other pairs, both toys looked identical, but they felt
different, for example a hard and a soft worm. At the beginning of each trial, the child saw and felt both toys in a pair and agreed on their properties, for example that they felt the same but looked different. Then the Experimenter held them both behind his back, mixed them up, and placed one on the table just out of the child’s reach, saying “Which one is it?” We were interested in whether children answered before or after touching the toy. One possibility was that children would always grab the toy before answering, even though this was unnecessary when the toy was identified by colour. Another possibility was that children would always answer without feeling the toy, even though feeling was necessary when the toy was either hard or soft.

In practice, children showed neither of these patterns. Instead, they were more likely to touch the toy before answering when it was either hard or soft, and to answer without touching it when it was identified by colour. Furthermore, children were no more or less likely to do nothing when that was sufficient, than to touch the toy when that was necessary. That is, as a group, children behaved as if they understood when feeling was necessary, and when looking was sufficient.

A second group of children played a similar game, but instead of placing the toy on the table, the Experimenter handed it to the child so that the child saw and felt it more or less simultaneously. Children in this group were asked “Which one is it?” and “How did you know it was the (hard) one?” Prompts were given if necessary, for example “Do you know because you saw it or because you felt it?” Children in this group had already received training trials in which they were told explicitly, for example, “You knew it was the hard one because you felt it”. As expected, children always identified the toy correctly. However, despite their training trials, they often were unable to report how they knew which toy it was.
In this experiment, then, children in the first group deliberately took the perceptual access that was necessary to identify the toy, yet those in the second group, who had both seen and felt the toy, appeared not to realise which was the informative modality of access. We cannot be too quick to interpret this as further evidence that children’s finding out behaviour reveals causal understanding not evident in their verbally explicit judgments. Children in the first, behavioural, group merely had to recognize whether or not they could identify the toy on seeing it, and act to gain further information if they could not. There was really only one way of gaining further information, and that was to touch the toy. Children may not have realised *touching* in particular was necessary to find out if the toy was hard or soft; we can infer only that they realised seeing was insufficient. In contrast, children in the second, explicit reporting, group had to identify which of their two modes of access to the toy (seeing and feeling) was the informative one. For example, they had to understand that touching in particular was the source of their knowledge about the toy’s hardness. That is, the behavioural and explicit tasks were not tapping the same casual understanding.

We therefore devised a behavioural (finding out) task that demanded the more complex understanding that seems to be assessed in the explicit task (“How do you know…?”) This experiment involved three-, four- and five-year-olds. The target toy was hidden in a box, similar to the task devised by O’Neill et al., (1992) and described in section 2.2. Whereas in O’Neill et al.’s experiment, children had to indicate how they would identify the toy, in this experiment children were simply asked to find out which toy it was (for example, the hard or the soft dog). Children could either see or feel it, since the apparatus did not allow them to do both at once. Would they choose the informative mode of access? Children performed poorly in this behavioural task, compared with their performance when they could already see the target toy and only had
to decide whether or not to feel it. They were no better at the more complex task than
they were at answering “How do you know?” after they had both seen and felt the hidden
toy.

In further studies we confirmed the conclusion from the experiments described in
this section so far: children acted to gain knowledge efficiently when they had only to
recognize whether or not they already had sufficient information to identify the target toy,
and there was only one additional modality of access to take when they had insufficient
information. They were much less efficient when they had a choice of modes of access.
Then, they seemed just to explore further to gain more information without being able to
predict the best way of finding out what they needed to know. That is, children who
recognized that they needed more information did not necessarily know what kind of
information they needed. Those who did know, were generally able also to report
explicitly how they knew.

**Summary.** In contrast to the findings reported in sections 3.1 and 3.2, in which
three- and four-year-olds ‘finding out behaviour was consistent with understanding the
causal connection between perceptual access and knowledge state, the tasks in this
section reveal weaknesses as well as strengths in children’s finding out behaviour. Under
simple conditions with limited choices (for example, ‘Having seen the toy, do I also need
to feel it [when that is the only other option]?’), three- and four-year-olds were efficient
at finding out more when that was necessary to identify the hidden toy. On the other
hand, when children that age had to choose between different modalities of access (‘Do I
need to see the toy or feel it?’), their finding out behaviour was not efficient. They
seemed simply to explore without predicting the best way of finding out what they
needed to know. Furthermore, there was no evidence that their finding out behaviour
revealed understanding not evident in their verbally explicit responses.
3.4 Conclusions from work on children’s finding out behaviour.

In section 2.4, the conclusion concerning children’s explicit, reflective understanding about the knowing process was that by five- to six- years of age, causal understanding is often clearly in evidence, in that children can report who knows what on the basis of what access, while many 3- and 4-year-olds demonstrate at best limited understanding. (Remember the proviso in that section that the ages offer only a rough guide.)

In contrast, the behavioural tasks discussed in sections 3.1, 3.2 and 3.3. summarize convincing evidence of understanding the causal connection between perceptual experience and knowledge amongst three- and four-year-olds. In section 3.1, children’s evaluations of the reliability of what they were told were consistent with understanding about the knowledge gained by the Experimenter on the basis of her perceptual access. Their behaviour seemed to be in advance of their explicit judgments of the Experimenter’s knowledge, and in advance of their explicit reports of the source of their own knowledge. In section 3.2, children revised their evaluations of the reliability of the Experimenter’s suggestion when doubts were expressed about the Experimenter’s access, consistent with understanding about knowledge sources. Here there was only weak evidence that this behaviour was in advance of children’s explicit reports of how they knew. Finally, in section 3.3, in which children aimed to identify a hidden toy for themselves rather than in interaction with the Experimenter, three- and four-year-olds efficiently took additional information access when it was necessary, and generally did not do so when they already had sufficient information to identify the hidden toy.

However, in the most demanding behavioural tasks in section 3.3, when behavioural and explicit judgments tasks drew on equivalent understanding of precisely
what knowledge is acquired from what perceptual experience, there was no evidence of finding out behaviour being in advance of explicit judgments.

In general, by examining children’s finding out behaviour, rather than just their ability to reflect and comment on the process of gaining knowledge, we might create a more fine-grained picture of the course of development of understanding of the causal connection between information access and knowledge state. However it is not simply the case that children’s behaviour is in advance of their explicit, reflective understanding. This is discussed further in the next section.

4. Children’s causal understanding of the knowing process: When and how?

As pointed out in the opening section, one difficulty associated with answering the question ‘when?’ is deciding what the child must do for the observing researcher to impute understanding of the causal connection between perceptual access and knowledge state. It is now clear that there is no single criterion, and no single point at which we would deem a child to have achieved understanding. Rather, between the ages of around three and six years, children show increasing mastery of the process of gaining knowledge from perceptual experience, mastery that relies on their making a causal connection between experience and knowledge state, and that includes being able to reflect on how knowledge was gained or predict how to gain particular knowledge.

In the opening section, two plausible patterns of results (and one implausible one) were specified: (i) children might show a pattern of finding out behaviour consistent with understanding a particular aspect of the knowing process, only when they can also reflect and report on it explicitly; (ii) finding out behaviour might to be in advance of reflective, explicit understanding. Results in line with pattern (i) would raise the question of the nature of the relationship between the ability to reflect on the process of gaining knowledge, and strategic behaviour: does the former cause the latter? Results in line with
pattern (ii) raise the question of the advantage of being able to reflect on the process of gaining knowledge if children behave efficiently and gain knowledge effectively without beginning able to do so.

As it turns out, both patterns appear in the results summarised in sections 2 and 3. Pattern (i) was found in section 3.3: children’s finding out behaviour was exploratory rather than strategic before they could report explicitly the source of the knowledge they had gained. Pattern (ii) was found in section 3.1: children appropriately believed or disbelieved what the well- or poorly-informed Experimenter told them despite being unable to report on sources of knowledge explicitly.

How should we resolve the finding that causal understanding as assessed by behavioural measures is sometimes in advance of explicit understanding, but sometimes is not? The mixed results seems to cast doubt on the usefulness of the suggestion offered in section 3.1, that the behavioural tasks could be seen as revealing implicit as opposed to explicit understanding, implicit understanding being seen as a lower level. Perhaps some more difficult finding out tasks, despite not requiring the child to comment explicitly on the process of gaining knowledge, nevertheless demand a similar level of reflective understanding. If so, how would we decide independently which of the finding out tasks fall into that category? Children’s spontaneous responses to “Which one is it?” when one of two toys was placed on the table in front of them (section 3.3: they felt the toy when that was necessary, but answered on the basis of looking when that was sufficient), seem uncontroversially to assess implicit rather than explicit understanding. On the other hand, when children were asked “Which one is it?” of a target toy hidden inside a box (section 3.3), perhaps reflective understanding was required – children found it just as difficult to select the informative modality of access as they did to report how they had found out.

Robinson, Haigh & Pendle (2008) describe a sequence of finding out tasks which move
in small steps from uncontroversially assessing only implicit understanding, to
uncontroversially assessing explicit, reflective understanding, but in which it is hard to
see where a step change takes place from assessing only implicit to assessing reflective
understanding. One challenge for the future is to characterize the various measures of
causal understanding in terms of their cognitive demands, and to develop an account of
the relationship between children’s finding out behaviour and their ability to reflect and
comment on the process of gaining knowledge.

Such an account would also move us forward in understanding how development
in causal understanding takes place. As mentioned in the opening section, at present we
know virtually nothing about the underlying processes responsible for the increases in
strategic, efficient finding out behaviour, or the increases in reflective awareness of how
particular perceptual experiences leads to knowledge. One possibility is that advances
occur simply as a result of experience exploring the world. If we gave a two-year-old
concentrated experience of different modalities of access, separated rather than combined
as they usually are in everyday life, would this be sufficient to allow her to show the
kinds of strategic finding out typical of five-year-olds without having developed the more
general cognitive skills typical of the older child? Some children in nurseries play games
intended to raise their awareness of the different modalities of access, but we do not
know how effective these are. Neither do we know what underlying conceptual and
general cognitive developments are necessary for children to advance in their causal
understanding.

One thing that does seem clear, however, is that young children whose causal
understanding about the process of gaining knowledge is still limited, are not seriously
hampered by their lack of understanding. By the age of three years, most children have
gained a large stock of knowledge as a result of their perceptual experiences. Incorrect
expectations about what knowledge can be gained from a particular experience can be
corrected with further exploration. For example, in the task described in section 3.3, with
the target toy hidden in a box, most of the children who initially felt it to identify its
colour, realised their mistake and went on to have a look. Similarly, most of the children
who initially looked at the toy to find out if it was hard or soft, realised their mistake and
went on to have a feel. They continued to explore until they gained the knowledge they
needed. Children who gain knowledge without knowing how they do so may not behave
as efficiently as those with more advanced understanding, but that understanding seems
not to be critical for learning about the physical world.

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