Origins of Mind
Lecture 04

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slide-3 The question for this course is … Our current question is about physical objects. How do humans first come to know simple facts about particular physical objects?

In attempting to answer this question, we are focussing on the abilities of infants in the first six months of life.

What have we found so far? …

slide-5 Recall the puzzle ….

slide-6 Berthier et al, Where's the ball reaching study

slide-8 More than two decades of research strongly supports the view that infants fail to search for objects hidden behind barriers or screens until around eight months of age (Meltzoff and Moore 1998, p. 202) or maybe even later (Moore and Meltzoff 2008). Researchers have carefully controlled for the possibility that infants' failures to search are due to extraneous demands on memory or the control of action. We must therefore conclude, I think, that four- and five-month-old infants do not have beliefs about the locations of briefly occluded objects. It is the absence of belief that explains their failures to search.

slide-10 Here's what we've found so far.

We examined how three requirements on having knowledge of physical objects are met. Knowledge of objects depends on abilities to (i) segment objects, (ii) represent them as persisting and (iii) track their interactions. To know simple facts about particular physical objects you need, minimally, to meet these three requirements.

The second discovery concerned how infants meet these three requirements this.

slide-11 The second was that a single set of principles is formally adequate to explain how someone could meet these requirements, and to describe infants' abilities with segmentation, representing objects as persisting and tracking objects' interactions.

This is exciting in several ways.

1. That infants have all of these abilities.
2. That their abilities are relatively sophisticated: it doesn't seem that we can characterise them as involving simple heuristics or relying merely on featural information.
3. That a single set of principles underlies all three capacities.

slide-12 three requirements, one set of principles: this suggests us that infants' capacities are characterised by a model of the physical.

slide-13 [slide: model] three requirements, one set of principles: this suggests us that infants' capacities are characterised by a model of the physical (as opposed to being a collection of unrelated capacities that only appear, but don't really, have anything to do with physical objects).

slide-14 1. How do four-month-old infants model physical objects?

In asking how infants model physical objects, we are seeking to understand not how physical objects in fact are but how they appear from the point of view of an individual or system.

The model need not be thought of as something used by the system: it is a tool the theorist uses in describing what the system is for and broadly how it works. This therefore leads us to a second question …

slide-15 2. What is the relation between the model and the infants?

slide-16 3. What is the relation between the model and the things modelled (physical objects)?

slide-21 Let's build on the simple view, extending it so that we do generate relevant predictions.

(There were also theoretical objections: maybe we can overcome these by extending it too.)

unit_665

The CLSTX Hypothesis: Object Indexes Underpin Infants' Abilities

slide-25 In adult humans, there is a system of object indexes which enables them to track potentially moving objects in ongoing actions such as visually tracking or reaching for objects, and which influences how their attention is allocated (Flombaum et al. 2008).

The leading, best defended hypothesis is that their abilities to do so depend on a system of object indexes like that which underpins multiple object tracking or object-specific preview benefits (Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007).

slide-26 But what is an object index? Formally, an object index is 'a mental token that functions as a pointer to an object' (Leslie et al. 1998, p. 11). If you imagine using your fingers to track moving objects, an object index is the mental counterpart of a finger (Pylyshyn 1989, p. 68).

Leslie et al say an object index is 'a mental token that functions as a pointer to an object' (Leslie et al. 1998, p. 11)

'Pylyshyn's FINST model: you have four or five indexes which can be attached to objects; it's a bit like having your fingers on an object: you might not know anything about the object, but you can say where it is relative to the other objects you're fingering. (ms. 19-20)' (Scholl and Leslie 1999)

The interesting thing about object indexes is that a system of object indexes (at least one, maybe more) appears to underpin cognitive processes which are not strictly perceptual but also do not involve beliefs or knowledge states. While I can't fully explain the evidence for this claim here, I do want to mention the two basic experimental tools that are used to investigate the existence of, and the principles underpinning, a system of object indexes which operates between perception and thought …

slide-27 Suppose you are shown a display involving eight stationary circles, like this one.

slide-28 Four of these circles flash, indicating that you should track these circles.

slide-29 All eight circles now begin to move around rapidly, and keep moving unpredictably for some time.

slide-30 Then they stop and one of the circles flashes. Your task is to say whether the flashing circle is one you were supposed to track. Adults are good at this task (Pylyshyn and Storm 1988), indicating that they can use at least four object indexes simultaneously.

(*Aside.* That this experiment provides evidence for the existence of a system of object indexes has been challenged. See Scholl (2009, p. 59):

> 'I suggest that what Pylyshyn's (2004) experiments show is exactly what they intuitively seem to show: We can keep track of the targets in MOT, but not which one is which. […] all of

> this seems easily explained [...] by the view that MOT is simply realized by split object-based attention to the MOT targets as a set.'

It is surely right that the existence of MOT does not, all by itself, provide support for the existence of a system of object indexes. However, contra what Scholl seems to be suggesting here, the MOT paradigm can be adapated to provide such evidence. Thus, for instance, Horowitz and Cohen (2010) show that, in a MOT paradigm, observers can report the direction of one or two targets without advance knowledge of which targets' directions they will be asked to report.)

slide-31 There is a behavioural marker of object-indexes called the object-specific preview benefit. Suppose that you are shown an array of two objects, as depicted here. At the start a letter appears briefly on each object. (It is not important that letters are used; in theory, any readily distinguishable features should work.)

slide-32 The objects now start moving.

slide-33 At the end of the task, a letter appears on one of the objects. Your task is to say whether this letter is one of the letters that appeared at the start or whether it is a new letter. Consider just those cases in which the answer is yes: the letter at the end is one of those which you saw at the start. Of interest is how long this takes you to respond in two cases: when the letter appears on the same object at the start and end, and, in contrast, when the letter appears on one object at the start and a different object at the end. It turns out that most people can answer the question more quickly in the first case. That is, they are faster when a letter appears on the same object twice than when it appears on two different objects (Kahneman et al. 1992). This difference in response times is the *object-specific preview benefit*. Its existence shows that, in this task, you are keeping track of which object is which as they move. This is why the existence of an object-specific preview benefit is taken to be evidence that object indexes exist.

The *object-specific preview benefit* is the reduction in time needed to identify that a letter (or other feature) matches a target presented earlier when the letter and target both appear on the same object rather than on different objects.

slide-34 To see the need for principles, return to the old-fashioned logistician who is keeping track of supply trucks. In doing this she has only quite limited information to go on. She receives sporadic reports that a supply truck has been sighted at one or another location. But these reports do not specify which supply truck is at that location. She must therefore work out which pin to move to the newly reported location. In doing this she might rely on assumptions about the trucks' movements being constrained to trace continuous paths, and about the direction and speed of the trucks typically remaining constant. These assumptions allow her to use the sporadic reports that some truck or other is there in forming views about the routes a particular truck has taken. A system of object indexes faces the same problem when the indexed objects are not continuously perceptible. What assumptions or principles are used to determine whether this object at time t_1 and that object at time t_2 have the same object index pinned to them?

slide-35 [object indexes and segmentation: ducks picture] Is one object index assigned or two? Assigning object indexes requires segmentation.

slide-36 [object indexes and segmentation: partially occluded stick]

slide-37 Consider a stick moving behind a screen, so that the middle part of it is occluded. Assigning one index even though there is no information about continuity of surfaces may depend on analysis of motion.

slide-38 [object indexes and representing occluded objects]

[Here we're interested in the issue rather than the details: the point is just that continuity of motion is important for assigning and maintaining object indexes.]

Suppose object indexes are being used in tracking four or more objects simultaneously and one of these objects—call it the *first object*—disappears behind a barrier. Later two objects appear from behind the barrier, one on the far side of the barrier (call this the *far object*) and one close to the point where the object disappeared (call this the *near object*). If the system of object indexes relies on assumptions about speed and direction of movement, then the first object and the far object should be assigned the same object index. But this is not what typically happens. Instead it is likely that the first object and the near object are assigned the same object index.[1] If this were what always happened, then we could not fully explain how infants represent objects as persisting by appeal to object indexes because, at least in some cases, infants do use assumptions about speed and direction in interpolating the locations of briefly unperceived objects. There would be a discrepancy between the Principles of Object Perception which characterise how infants represent objects as persisting and the principles that describe how object indexes work.

But this is not the whole story about object indexes. It turns out that object indexes behave differently when just one object is being tracked and the object-specific preview benefit is used to detect them. In this case it seems

[1] See Franconeri et al. (2012). Note that this corrects an earlier argument for a contrary view (Scholl and Pylyshyn 1999).

that assumptions about continuity and constancy in speed and direction do play a role in determining whether an object at t_1 and an object at t_2 are assigned the same object indexes (Flombaum and Scholl 2006; Mitroff and Alvarez 2007). In the terms introduced in the previous paragraph, in this case where just one object is being tracked, the first object and the far object are assigned the same object index. This suggests that the principles which govern object indexes may match the principles which characterise how infants represent objects as persisting.

slide-39 [object indexes and representing causal interactions]

slide-40 The Principles of Object Perception are the key to specifying one way of meeting these three requirements.

This suggests that, maybe, The Principles of Object Perception which characterise infants' abilities to track physical objects also characterise the operations of a system of object indexes.

slide-41 *The CLSTX conjecture* Infants' abilities concerning physical objects are characterised by the Principles of Object Perception because infants' abilities are a consequence of the operations of a system of object indexes (Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007).

('CLSTX' stands for Carey-Leslie-Scholl-Tremoulet-Xu (see Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007)) Their upshot is not knowledge about particular objects and their movements but rather a perceptual representation involving an object index.

One reason the hypothesis seems like a good bet is that object indexes are the kind of thing which could in principle explain infants' abilities to track unperceived objects because object indexes can, within limits, survive occlusion.

Note that the CLSTX conjecture assumes that the Principles of Object Perception which characterise infants' abilities to track physical objects also characterise the operations of a system of object indexes.

:t reflecting on McCurry et al. (2009) in one of the seminars … distinguished initiating action and continuing to perform an action … object indexes support guidance of action but not its initiation.

This amazing discovery is going to take us a while to fully digest. As a first step, note its significance for Davidson's challenge about characterising what is going on in the head of the child who has a few words, or even no words. [2]

[2] The findings cited in this paragraph all involve measuring object-specific preview benefits. Some researchers have argued that in multiple object tracking with at least four ob-

slide-42 2. What is the relation between the model and the infants?

slide-46 behavioural: OSPB-like-effect (Richardson & Kirkham; note their caveats); neural Kaufmann, Csibra et al

If we consider six-month-olds, we can also find behavioural markers of object indexes in infants (Richardson and Kirkham 2004) …

slide-47 … and there are is also a report of neural markers too (Kaufman et al. 2005).

slide-48 (Kaufman et al. (2005) measured brain activity in six-month-olds infants as they observed a display typical of an object disappearing behind a barrier. (EEG gama oscillation over right temporal cortex) They found the pattern of brain activity characteristic of maintaining an object index. This suggests that in infants, as in adults, object indexes can attach to objects that are briefly unperceived.)

slide-49 The evidence we have so far gets us as far as saying, in effect, that someone capable of committing a murder was in the right place at the right time. Can we go beyond such circumstantial evidence?

slide-50 The key to doing this is to exploit signature limits.

A *signature limit of a system* is a pattern of behaviour the system exhibits which is both defective given what the system is for and peculiar to that system.

Carey (2009) argues that what I am calling the signature limits of object indexes in adults are related to signature limits on infants' abilities to track briefly occluded objects.

slide-51 To illustrate, a moment ago I mentioned that one signature limit of object indexes is that featural information sometimes fails to influence how objects are assigned in ways that seem quite dramatic.

slide-52 There is evidence that, similarly, even 10-month-olds will sometimes ignore featural information in tracking occluded objects (Xu and Carey

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jects, motion information is not used to update indexes during the occlusion of the corresponding objects (Keane and Pylyshyn 2006; Horowitz et al. 2006); rather, 'MOT through occlusion seems to rely on a simple heuristic based only on the proximity of reappearance locations to the objects' last known preocclusion locations' (Franconeri et al. 2012, p. 700). However information about motion is sometimes available (Horowitz and Cohen 2010) and used in tracking multiple objects simultaneously (Howe and Holcombe 2012; St Clair 2012). One possibility is that, in tracking four objects simultaneously, motion information can be used to distinguish targets from distractors but not to predict the future positions of objects (Howe and Holcombe 2012, p. 8).

1996).[3]

slide-54 *The CLSTX conjecture* Infants' abilities concerning physical objects are characterised by the Principles of Object Perception because infants' abilities are a consequence of the operations of a system of object indexes (Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007).

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While I wouldn't want to suggest that the evidence on siganture limits is decisive, I think it does motivate considering the hypothesis and its consequences. In what follows I will assume the hypothesis is true: infants' abilities to track briefly occluded objects depend on a system of object indexes.

slide-55 How does help us with the puzzles?

slide-56 Object indexes can survive occlusion ...

slide-57 ... but not the endarkening of a scence

slide-58 But why do we get the opposite pattern with search measures?

slide-60 The hypothesis has an advantage which I don't think is widely recognised. This is that object indexes are independent of beliefs and knowledge states. Having an object index pointing to a location is not the same thing as believing that an object is there. And nor is having an object index pointing to a series of locations over time is the same thing as believing or knowing that these locations are points on the path of a single object. Further, the assignments of object indexes do not invariably give rise to beliefs and need not match your beliefs.

To emphasise this point, consider once more this scenario in which a patterned square disappears behind the barrier; later a plain black ring emerges. You probably don't believe that they are the same object, but they probably do get assigned the same object index. Your beliefs and assignments of object

[3] This argument is complicated by evidence that infants around 10 months of age do not always fail to use featural information appropriately in representing objects as persisting (Wilcox and Chapa 2002). In fact McCurry et al. (2009) report evidence that even five-month-olds can make use of featural information in representing objects as persisting (see also Wilcox 1999). Likewise, object indexes are not always updated in ways that amount to ignoring featural information (Hollingworth and Franconeri 2009; Moore et al. 2010). It remains to be seen whether there is really an exact match between the signature limit on object indexes and the signature limit on four-month-olds' abilities to represent objects as persisting. The hypothesis under consideration—that infants' abilities to track briefly occluded objects depend on a system of object indexes like that which underpins multiple object tracking or object-specific preview benefits—is a bet on the match being exact.

indexes are inconsistent in this sense: the world cannot be such that both are correct.

slide-62 So this is a virtue of the hypothesis that four- and five-month-old infants' abilities to track briefly occluded objects depend on a system of object indexes. Since assignments of object indexes do not entail the existence of corresponding beliefs, the fact that infants of this age systematically fail to search for briefly occluded objects is not an objection to the hypothesis.

slide-63 So why do 5 month olds fail to manifest their ability to track briefly occluded objects by initiating searches for them after they have been fully occluded?

slide-64 Because object indexes are independent of beliefs and do not by themselves support the initiation of action. Further, I guess that occlusion interferes with motor representations of objects in infants because occlusion involves two objects, one in front of the other.

slide-65 But we still have to explain this …

Why do infants succeed in searching for momentarily endarkend objects? Because they can represent objects motorically, and endarkening does not immediately interfere with such representations. What does this mean?

slide-68 Object indexes survive occlusion but not endarkening; motor representations survive endarkening but not occlusion.

slide-69 Why do 5 month old infants reach towards the cloth screen more often when a cube goes in and a circle comes out than when a cube goes in and a cube comes out?

Here's the authors' description of their procedure. 'Once the ball came to rest at the right edge of the platform, the platform was pushed forward until the edge of the platform was directly in front of, and within easy reach of, the infant. In the second phase, the infant was allowed to search for 20 s. ' (McCurry et al. 2009)

What should we predict? Cloth screen does not prevent action,[4] so reaching should be possible. Further, if motor representations are responsible for the effect, the fact that the experiment requires sensitivity to featural information should not be an issue. (Further, a version of this task using violation of expectations may fail because featural information is critical.) And although

[4] 'In the first familiarization trial, infants were shown the fringed-screen and were encouraged to reach through the fringe. If necessary, the experimenter gently guided the infant's hand through the fringed-screen. Once the infant placed his or her hand through the fringed-screen twice, the trial ended.'

these are very far from the terms in which they interpret their findings, this is exactly what McCurry et al 2009 found.

slide-71 Object indexes survive occlusion but not endarkening; motor representations survive endarkening but not occlusion.

slide-73 *The CLSTX conjecture* Infants' abilities concerning physical objects are characterised by the Principles of Object Perception because infants' abilities are a consequence of the operations of a system of object indexes (Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007).

('CLSTX' stands for Carey-Leslie-Scholl-Tremoulet-Xu (see Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007))

slide-74 Return to this amazing discovery.

2. What is the relation between the model and the infants?

unit_669

Core Knowledge vs Object Indexes

Consider the conjecture that infants' abilities concerning physical objects are characterised by the Principles of Object Perception because infants' abilities are a consequence of the operations of a system of object indexes. If this conjecture is true, should we reject the claim that infants have a core system for physical objects? Or does having a system of object indexes whose operations are characterised by the Principles of Object Perception amount to having core knowledge of those principles?

Outstanding problem Since having core knowledge of objects does not imply having knowledge knowledge of objects, how can the emergence in development of knowledge of simple facts about particular physical objects be explained? What is the role of core knowledge of objects, and what other factors might be involved?

slide-76 Let's consider some consequences of the CLSTX conjecture. *The CLSTX conjecture* Infants' abilities concerning physical objects are characterised by the Principles of Object Perception because infants' abilities are a consequence of the operations of a system of object indexes (Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007).

('CLSTX' stands for Carey-Leslie-Scholl-Tremoulet-Xu (see Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007))

slide-77 We saw this quote in the first lecture …

slide-78 Actually we don't lack a way of describing what is in between. We already have it. We were simply not aware of it because we hadn't thought carefully enough about the representations and processes involved in perception and action.

The discovery that the principles of object perception characterise the operation of object-indexes doesn't mean we have met the challenge exactly. We haven't found a way of describing the processes and representations that underpin infants' abilities to deal with objects and causes. However, we have reduced the problem of doing this to the problem of characterising how some perceptual mechanisms work. And this shows, importantly, that understanding infants' minds is not something different from understanding adults' minds, contrary to what Davidson assumes. The problem is not that their cognition is half-formed or in an intermediate state. The problem is just that understanding perception requires science and not just intuition.

slide-79 What is the relation between infants' competencies with objects and adults'? Is it that infants' competencies grow into more sophisticated adult competencies? Or is it that they remain constant throught development, and are supplemented by quite separate abilities?

slide-83 The identification of the Principles of Object Perception with object-indexes suggests that infants' abilities are constant throughout development. They do not become adult conceptual abilities; rather they remain as perceptual systems that somehow underlie later-developing abilities to acquire knowledge.

Confirmation for this view comes from considering that there are discrepancies in adults' performances which resemble the discrepancies in infants between looking and action-based measures of competence … [This links to unit 271 on perceptual expectations …]

slide-85 Which of these features are features of a system of object indexes?

slide-92 Left half: The Core Knowledge View

Infants, like most adults, do not know the principles of object perception; but they have core knowledege of them.

The CLSTX conjecture

The principles of object perception characterise how a system of object indexes should work.

Infants' (and adults') object indexes track objects through occlusion.

Five-month-olds do not know the location of an occluded object.

Five-month-olds do have perceptual expectations concerning its location.

‘CLSTX’ stands for Carey-Leslie-Scholl-Tremoulet-Xu (see Leslie et al. 1998; Scholl and Leslie 1999; Carey and Xu 2001; Scholl 2007)

Are these two views compatible? I think we had better characterise core knowledge in such a way that they turn out to be true!

slide-93 Our Next Big Problem is this. We’ve said that infants’ competence with causes and objects is not knowledge but something more primitive than knowledge, something which exists in adults too and can carry information discrepant with what they know. So, if at all, how does appealing to these early capacities enable us to explain the origins of knowledge?

slide-94 Berthier et al, Where’s the ball reaching study

Further issue … we now have a more complicated story about the emergence of knowledge

slide-95 Broadly, my suggestion will be that the competence which appears in the first months of development leads to knowledge of objects and causes only in conjunction with various additional things, like social interaction, perhaps language and abilities to use tools.

The picture I want to offer differs from those of researchers like Vygotsky and Tomasello in that there is an essential role for early-developing forms of representation that are more primitive that concepts or thoughts and do not appear to have any kind of social origin.

But the picture also differs from those of researchers like Spelke and Carey in that these early developing forms of representation are only one of several components that are needed to understand the origins of knowledge.

To explore this idea I want to switch to a completely different domain, colour.

[*Aside on tool use:] Basic forms of tool use may not require understanding how objects interact (Barrett, Davis, & Needham; Lockman, 2000), and may depend on core cognition of contact-mechanics (Goldenberg & Hagmann, 1998; Johnson-Frey, 2004). Experience of tool use may in turn assist children in understanding notions of manipulation, a key causal notion (Menzies & Price, 1993; Woodward, 2003). Perhaps non-core capacities for causal representation are not innate but originate with experiences of tool use.

unit_667

Phenomenal Expectations Connect Object Indexes to Looking Behaviours

slide-97 So those who, like me, are impressed by the evidence for the hypothesis that four- and five-month-olds’ abilities to track occluded objects are underpinned by the operations of a system of object indexes are left with a question. The question is, What links the operations of object indexes to patterns in looking duration?

I've just argued that it can't be beliefs or knowledge states. So far we've been assuming it is object indexes. But this assumption is not quite right …

slide-98 This is an important question for me so I want to pause to emphasise it. This question is, What can the operations of a system of object indexes explain?

slide-99 Functions of object indexes:

✓ influence how attention is allocated

✓ guide ongoing actions (e.g. visual tracking, reaching)

✗ initiate purposive actions

If these are the functions of object indexes, how can we explain looking times in habituation or violation-of-expectation experiments?

The primary functions of object indexes include influencing the allocation of attention and perhaps guiding ongoing action. If this is right, it may be possible to explain anticipatory looking directly by appeal to the operations of object indexes. But the operations of object indexes cannot directly explain differences in how novel things are to an infant. And nor can the operations of object indexes directly explain why infants look longer at stimuli involving discrepancies in the physical behaviour of objects.

slide-100 Consider this case where a ball falls and lands on a bench. Suppose that there was a barrier in front of the bench, like the dotted line. Because the bench protrudes from the barrier, you could easily see where the ball will land. But of course you can only see this if you know that barriers stop solid balls. Spelke used this observation to provide evidence that 4-month-old infants can track objects' causal interactions.

Infants were habituated to a display in which a ball fell behind a screen, the screen came forwards and the ball was revealed to be on the ground, just where you'd expect it to be. After habituation infants were shown one of two displays. Infants in the 'consistent group' were shown this.

Whereas infants in the 'inconsistent group' were shown this.

What should we predict? If infants were only paying attention to the shapes and ignoring properties like solid, they should have dishabituated more to the consistent than to the inconsistent stimlus. After all, that stimlus is more different from the habituation stimulus in terms of the surfaces. But if infants were are to track some simple causal interactions, then they might dishabituate to the 'inconsistent' stimulus more than to the 'consistent' stimulus because that one involves an apparent violation of a physical laws.

slide-101 Here are the results.

(Recall that the subjects are 4-month-old infants.)

Why do infants manifest an ability to track briefly occluded objects on habituation and violoation-of-expectations tasks? Ah … just here we face a significant challenge …

As I said earlier, infants' abilities to track briefly occluded objects are manifested in several different ways. They are manifested in (iii) anticipatory looking, (ii) reactions indicating the violation of an expectation, and (i) dishabituation indicating interest in certain stimuli.

Can all of these behaviours be explained merely by invoking object indexes?

We know that infants are likely to maintain object indexes for the object while it is they are occluded. Accordingly, when the screen drops in the condition labelled 'impossible outcome', there is an interruption to the normal operation of object indexes: infants have assigned two object indexes but there is only one object. But why does this cause infants to look longer at in the 'impossible outcome' condition than in the 'possible outcome' condition? **How does a difference in operations involving object indexes result in a difference in looking times?**

slide-102 Recall this situation. Suppose you have seen it a hundred times before, so you know just what to expect. Still, the tendancy to expect two objects is on some level barely diminished, and event in which a single object is revealled is liable to feel magical in some small way. This feeling of magic is a phenomenal expectation.

Let me give you two more illustrations [the wire and the face]. …

———

slide-104 Now I want to suggest that it is something called a phenomenal expectation.

Before I explain what phenomenal expectations are, let me illustrate the idea informally.

slide-105 What is a phenomenal expectation? Consider a second illustration.

Here is a wire. Contrast two sensory encounters with this wire. In the first you visually experience the wire as having a certain shape. In the second you receive an electric shock from the wire without seeing or touching it.[5] The first sensory encounter involves perceptual experience as of a property of the wire whereas, intuitively, the second does not. I take this intuition to be correct.[6]

The intuition is potentially revealing because the electric shock involves rich phenomenology, and its particular phenomenal character depends in part on properties of its cause (changes in the strength of the electric current would have resulted in an encounter with different phenomenal character). So there are sensory encounters which, despite having phenomenal characters that depend in part on which properties are encountered, are not perceptual experiences as of those properties.

slide-106 What is a phenomenal expectation? Consider a third (and final) illustration.

Here is a face that I hope will seems familiar to most people. When you see this face, you have a feeling of familiarity. This feeling of familiarity is not just a matter of belief: even if you know for sure that you have never encountered the person depicted here (and trust me, you haven't), the feeling of familiarity will persist. Nor is the feeling a matter of perceptual experience: you can't perceptually experience familiarity any more than you can perceptually experience electricity.

(The face is a composite of Bush and Obama. It is chosen to illustrate that the feeling of familiarity is not a consequence of how familiar things actually are; instead it may be a consequnece of the degree of fluency with which unconscious processes can identify perceived items (Whittlesea 1993; Whittlesea and Williams 1998). Learning a grammar can also generate feelings of familiarity. Subjects who have implicitly learned an artificial grammar report feelings of familiarity when they encounter novel stimuli that are part of the learnt grammar (Scott and Dienes 2008). They are also not doomed to treat feelings of familiarity as being about actual familiarity: instead subjects can use feeling of familiarity in deciding whether a stimulus is from that grammar (Wan et al. 2008).)

I could go on to mention the feeling you have when someone's eyes are boring into your back, or the feeling that a name is on the tip of your tongue.

[5] This illustration is borrowed from Campbell (2002: 133–4); I use it to support a claim weaker than his.

[6] Notice that the intuition is not that the shock involves no perceptual experience at all, only that the shock does not involve perceptual experience as of any property of the wire. Notice also that the intuition concerns what a perceptual experience is as of, and not directly what is represented in perception. The relation between these two is arguably not straightforward (compare, e.g., Shoemaker (1994, p. 28) or Chalmers (2006, pp. 50–2) on distinguishing representational from phenomenal content).

But let me focus just on the feelings associated with electricity and with familiarity. These feelings are paradigm cases of phenomenal expectation.

slide-107 All three examples (the feelings of magic, of electricity and of familiarity) show that:

There are aspects of the overall phenomenal character of experiences which their subjects take to be informative about things that are only distantly related (if at all) to the things that those experiences intentionally relate the subject to.

To illustrate, having a feeling of familiarity is not a matter of standing in any intentional relation to the property of familiarity, but it is something that we can interpret as informative about famility.

slide-108 Phenomenal expectations are these aspects of experience.

slide-109 Phenomenal expectations can be thought of as sensations in approximately Reid's sense.[7]

slide-110 Sensations are:

1. monadic properties of events, specifically perceptual experiences,
2. individuated by their normal causes—in the case of feelings of familiarity, its normal cause is ease of processing
3. which alter the overall phenomenal character of those experiences
4. in ways not determined by the experiences' contents (so two perceptual experiences can have the same content while one has a sensational property which the other lacks).

slide-111 An important consequence is that phenomenal expectations can lead to beliefs only via associations or further beliefs. They are signs which need to be interpreted by their subjects (Reid 1785a, Essay II, Chap. 16, p. 228 Reid 1785b, Chap. VI sect. III, pp. 164–5). Let me explain.

As a scientist, you can pick out the feeling of familiarity as that phenomenal expectation which is normally caused by the degree to which certain

7 Reid (1785a,b). Even if you don't believe that there are sensations in Reid's sense, thinking of phenomenal expectations as if they were sensations will serve to illustrate their characteristic features. The main points that follow are consistent with several different ways of thinking about phenomenal expectations. For instance, you might take the view that what I am calling phenomenal expectations are perceptual experiences of the body or of bodily reactions, or that they involve some kind of cognitive phenomenology. The essential claim is just that the phenomenal expectations associated with the operations of object indexes are not constituted by states which involve intentional relations to any of the things which are assigned an object index.

processes are fluent. But as the subject of who has that phenomenal expectation, you do not necessarily know what its typical causes are. This is something you have to work out in whatever ways you work out the causes of any other type of event.

(Contrast phenomenal expectations with perceptual experiences. Having a perceptual experience of, say, a wire's shape, involves standing in an intentional relation to the wire's shape; and the phenomenal character of this perceptual experience is specified by this intentional relation.[8] Such perceptual experiences are often held to reveal the wire's shape to the subject and so lead directly to beliefs.[9])

(By contrast, having a phenomenal expectation concerning familiarity or an physical object's path does not involve standing in any intentional relation to these things. The phenomenal expectation is individuated by its normal causes, rather than by any intentional relation. And a phenomenal expectation leads to belief, if at all, only indirectly. For learning is required in order for the subject to come to a view on what tends to cause the phenomenal expectation.)

Phenomenal expectations have been quite widely neglected in philosophy and developmental psychology. They are a means by which cognitive processes enable perceivers to acquire dispositions to form beliefs about objects' properties which are reliably true. Phenomenal expectations provide a low-cost but efficient bridge between non-conscious cognitive processes and conscious reasoning.

slide-112 So my question was how the operations of object indexes might explain patterns of looking duration in habituation and violation-of-expectation experiments. My guess is that some operations of object indexes give rise to phenomenal expectations, which in turn influence looking durations.

slide-113

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[8] Compare Martin (2002, p. 380): 'I attend to what it is like for me to inspect the lavender bush through perceptually attending to the bush itself.' And Byrne (2001, p. 211) 'subject can only discover the phenomenal character of her experience by attending to the world … as her experience represents it.'

[9] Compare Johnston (1992, p. 222): '[j]ustified belief … is available simply on the basis of visual perception'; Tye (1995, p. 143–4): 'Phenomenal character "stands ready … to make a direct impact on beliefs'; and Smith (2001, p. 291): '[p]erceptual experiences are … intrinsically … belief-inducing.'

Development Is Rediscovery

This guess gives rise to a further question (which I want to articulate but won't attempt to answer). In asking how the operations of object indexes might give rise to patterns in looking duration, we have been concerned with what happens a short interval of time. But the guess about phenomenal expectations raises a question about the course of development in the first months or years of life. Let me explain.

slide-114 In the beginning Spelke and others conjectured that infants' abilities to track briefly occluded objects were a consequence of their having core knowledge for objects. This conjecture is related to the later hypothesis about object indexes. The idea is that we can further specify the mechanisms that realise infants' core knowledge of physical objects by identifying it with two things: a system of object indexes and a system capable of representing physical objects motorically.

slide-115 There was always a question about how infants' core knowledge about objects might explain the emergence of knowledge knowledge (that is, knowledge proper) about objects. Now this question becomes, What is the role of a system of object indexes in the emergence in development of knowledge of physical objects? In short, How do you get from object indexes to knowledge?

Answers to these questions typically assume that core knowledge provides a conceptual identification of objects and some of their properties such as location or size, or else that it involves standing in some kind of intentional relation to these things. This is true of Spelke's suggestion that mature understanding of objects, number, and mind derives from core knowledge by virtue of core knowledge representations being assembled (Spelke 2000); claims by Leslie and others that modules provide conceptual identifications of their inputs (Leslie 1988); Karmiloff-Smith's representational re-description (Karmiloff-Smith 1992); and Mandler's claim that 'the earliest conceptual functioning consists of a redescription of perceptual structure' (Mandler 1992).

slide-116 But recall the guess about phenomenal expectations linking object indexes to patterns of looking duration. If this guess is right, then it is not true that core knowledge provides a conceptual identification of objects. And it is not true that having core knowledge involves standing in any kind of intentional relation to objects and their properties. This makes the question about development particularly difficult to answer.

It means that rather than assembing or redescribing representations, development must be a process of rediscovery.

The step from phenomenal expectations to knowledge is like the step from feeling electric shocks to understanding electricity. So coming to know simple facts about particular physical objects may begin with object indexes and the phenomenal expectations these give rise to, but it does not end there. Interpreting the phenomenal expectations may involve interacting with objects, learning to use tools, and perhaps interacting with others and objects simultaneously.

Coming to know facts about physical objects is a matter of rediscovering things already implicit in a system of object indexes. Some might object that development can't require such rediscovery because it would be hopelessly inefficient to require things already encoded to be learnt anew. But rediscovery is an elegant solution to a practical problem. If you are building a survival system you want quick and dirty heuristics that are good enough to keep it alive: you don't necessarily care about the truth. If, by contrast, you are building a thinker, you want her to be able to think things that are true irrespective of their survival value. This cuts two ways. On the one hand, you want the thinker's thoughts not to be constrained by heuristics that ensure her survival. On the other hand, in allowing the thinker freedom to pursue the truth there is an excellent chance she will end up profoundly mistaken or deeply confused about the nature of physical objects. So you don't want thought contaminated by survival heuristics and you don't want survival heuristics contaminated by thought. Or, even if some contamination is inevitable, you want to limit it. This combination is beautifully achieved by giving your thinker a system or some systems for tracking objects and their interactions which appear early in development, and also a mind which allows her to acquire knowledge of physical objects gradually over months or years, taking advantage of interactions with objects as well as social interactions about objects—providing, of course, that the two are not directly connected but rather linked only very loosely, via phenomenal expectations.

slide-118

Conclusion

To conclude, I started by mentioning the wide variety of evidence that four- and five-month-olds can track briefly occluded objects. This evidence raises the question, How do infants do that? On the leading, best supported hypothesis, four- and five-month-olds' abilities to track briefly occluded objects depend on a system of object indexes like that which underpins multiple object tracking or object-specific preview benefits. This hypothesis also has the virtue of being consistent with the most straightforward explanation of why infants of this age (four- to five-months) and even older systematically fail to manually search for occluded objects. (The explanation is that they lack beliefs about the locations of objects.)

Accepting this hypothesis forces us to confront a question. How could the operations of object indexes explain patterns in looking duration? This question arises because facts about the operations of object indexes do not themselves straightforwardly imply anything about how things seem to infants, nor about what they believe.

The answer, I suggested, is phenomenal expectations. Much as there are phenomenal expectations associated with the ease or difficulty of processing a complex stimulus like a face or letter sequence, so also phenomenal expectations are associated with operations involving object indexes. These phenomenal expectations are not intentional relations to the phyiscal objects whose behaviours normally cause them. Instead they can be thought of as sensations in roughly Reid's sense. So they are monadic properties of perceptual experiences which carry information about physical objects.

Importantly, phenomenal expectations (like sensations) require interpretation. In order to get from a phenomenal expectation to a belief you need to form a view about what the phenomenal expectation is a sign of. This requires learning, and your view can change as you learn more.

This has consequences for understanding the emergence in development of knowledge of physical objects. Such knowledge is probably a consequence of the (core) system of object indexes, but on the view I have been defending the two can be only indirectly related. Having core knowledge of objects is a matter of having a system of object indexes. The system can affect what you believe or know about objects only by way of phenomenal expectations. Gaining knowledge proper requires interpreting the phenomenal expectations, and so is in part a matter of rediscovering information already processed by your core systems.

slide-119 The question is … How do humans first come to know simple facts about particular physical objects?

slide-120 Here's what we've found so far.

We examined how three requirements on having knowledge of physical objects are met. Knowledge of objects depends on abilities to (i) segment objects, (ii) represent them as persisting and (iii) track their interactions. To know simple facts about particular physical objects you need, minimally, to meet these three requirements.

The second discovery concerned how infants meet these three requirements this.

slide-121 The second was that a single set of principles is formally adequate to explain how someone could meet these requirements, and to describe infants' abilities with segmentation, representing objects as persisting and tracking objects' interactions.

This is exciting in several ways.

1. That infants have all of these abilities.
2. That their abilities are relatively sophisticated: it doesn't seem that we can characterise them as involving simple heuristics or relying merely on featural information.
3. That a single set of principles underlies all three capacities.

slide-122 Return to this amazing discovery.

2. What is the relation between the model and the infants?

Let me make some more points about it.

First, it works in concert with a claim about motor representation. We neeed this claim otherwise we haven't fully explained the discrepancy between looking and action-based measures for representing objects as persisting and tracking their causal interactions. After all, why do these perceptual representations of objects–the object indexes–not guide purposive actions like reaching and pulling? This is an issue we shall return to.

Second, it leaves us with a question we didn't have before. What is the relation between these abilities to segment objects, represent them as persisting and track their causal interactions and knowledge about objects? Clearly having an object-index stuck to an object is not the same thing as having knowledge about the object's location and movements. (If it were, we'd face just the problems that are fatal for the Simple View.) What then is the relation between these things?

slide-123 Only phenomenal expectations

connect 'core knowledge' of objects

to thought.

Phenomenal expectations have been quite widely neglected in philosophy and developmental psychology. They are a means by which cognitive processes enable perceivers to acquire dispositions to form beliefs about objects' properties which are reliably true. Phenomenal expectations provide a low-cost but efficient bridge between non-conscious cognitive processes and conscious reasoning.

Development is rediscovery.

If you accept my story about phenomenal expectations then you also face a problem understanding the how the existence of core knowledge systems can explain the emergence of knowledge in development.

If you accept my story about phenomenal expectations then you also face a problem understanding the how the existence of core knowledge systems can explain the emergence of knowledge in development.

unit_641

Syntax / Innateness

slide-125 So far we have considered examples of core knowledge. But we have ignored a paradigm case, one which has inspired much work on this topic (although it is not a case Spelke or Carey would recognize! *todo: stress throughout) …

slide-126 Human adults have extensive knowledge of the syntax of their languages, as illustrated by, for example, their abilities to detect grammatical and ungramatical sentences which they have never heard before, independently of their meanings. To adapt a famous example from Chomsky, …

slide-127 We need to task two questions.

slide-128 First, what is this thing, syntax, which is known?

This thing they know, the syntax, isn't plausibly just a list of which sentences are grammatical.

Because people can make judgements about arbitrarily long, entirely novel sentences.

Rather, the thing known must be something that enables people to make judgements about sentences.

We might think of it roughly as a theory of syntax.

It's like a theory in this sense: knowledge of it enables you to make judgements about the grammaticality of arbitrary sentences.

slide-129 The second question is, Is it *knowledge* we have syntax or something else?

There's something interesting.

The knowledge can be revealed indirectly, by asking people about whether particular sentences are grammatical.

But people can't say anything about how they know the sentence is grammatical.

It's like perceiving the shape of something: there isn't much to say about how you know.

So the theory of syntax isn't something we can discover by introspection:

we have to *rediscover* it from scratch by investigating people's linguistic abilities.

slide-130 Knowledge of syntax therefore seems to have some of the features associated with core knowledge.

First, it is domain-specific.

Second, it is inaccessible. That is, it can't guide arbitrary actions.

In what follows I want to suggest that syntax provides a paradigm case for thinking about core knowledge.

slide-131 In addition, I want to use the case of syntax for thinking about the question, What is innate in humans?

I was astonished how many people considered this question in the unassessed essay, some people seem really fascinated by it.

But almost no one discussed the case of syntax in depth. If you're going to talk about innateness, you really need to know a little bit about syntax.

So I'm also going to provide you with that understanding.

slide-132 Consider a phrase like 'the red ball'.

What is the syntactic structure of this noun phrase?

In principle there are two possibilities.

slide-135 How can we decide between these?

1. 'red ball' is a constituent on (b) but not on (a)
2. anaphoric pronouns can only refer to constituents
3. In the sentence 'I'll play with this red ball and you can play with that one.', the word 'one' is an anaphoric prononun that refers to 'red ball' (not just ball). (Lidz et al. 2003; Lidz and Waxman 2004).

slide-137 What I've just shown you is, in effect, how we can decide whihc way an adult human understands a phrase like 'the red ball'.

We can discover this by finding out how they understand a sentence like 'I'll play with this red ball and you can play with that one.'.

But how could we do this with infants who are incapable of discussing sentences with us?

slide-138 Here's how the experiment works (see Lidz et al. 2003) …

The experiment starts with a background assumption:

‘The assumption in the preferential looking task is that infants prefer to look at an image that matches the linguistic stimulus, if one is available’ (Lidz et al. 2003).

slide-139 So the key question was whether infants would look more at the yellow bottle (which is familiar) or the blue bottle (which is novel).

If they think ’one’ refers to ’bottle’, we’d expect them to look longer at the blue bottle;

and conversely if they think one refers to ’yellow bottle’, then they’re being asked whether they see another yellow bottle.

slide-140 And, as always, we need a control condition to check that infants aren’t looking in the ways predicted irrespective of the manipulation.

slide-141 And here’s what they found …

slide-142 What can we conclude so far?

So there is core knowledge of syntax … or is there?

slide-143 Core knowledge is often characterised as innate.

I think this is a mistake (more about this later), but many of you do not.

How could we tell whether these representations are innate?

slide-144 What do we mean by innate here?

The easy answer is: not learned.

But I think there’s a more interesting way to approach understanding what ’innate’ means.

Quite a few people pointed out that there isn’t agreement on what innateness is.

But this is not very interesting by itself because there’s disagreement about most things and potential causes of disagreement include ignorance and stupidity.

It’s also important that the mere fact that a single term is used with multiple meanings isn’t an objection to anyone.

As philosophers, some of you are tempted to catalogue different possible notions of innateness.

I encourage you to resist this temptation; if you want to collect something, pick something useful like banknotes.

There’s a much better way to approach things.

Let's see what kind of findings are, or would be, taken to show that something is innate.

We can use these to constrain our thinking about innateness.

We will say: assuming that this is a valid argument that X is innate, what could innateness be?

slide-145 Aside: we have too approach science as radical interpreters …

How does radical interpretation work?

Interpretation is hard because there are two factors: truth and meaning.

The proposal Davidson makes is that we assume truth and infer meaning.

I'm recommending a similar strategy.

We take for granted that this argument establishes that X is innate; we then ask what innateness could be given that this is so.

'All understanding of the speech of another involves radical interpretation' (Davidson 1973, p. 125)

slide-146 The best argument for innateness is the poverty of stimulus argument.

We need to step back and understand how poverty of stimulus arguments work.

Here I'm following Pullum and Scholz (2002), but I'm simplifying their presentation.

How do poverty of stimulus arguments work? See Pullum and Scholz (2002).

First think of them in schematic terms …

This is a good structure; you can use it in all sorts of cases, including the one about chicks' object permanence.

Now fill in the details …

slide-153 In our case, X is knowledge of the syntactic structure of noun phrases. (Caution: this is a simplification; seeLidz and Waxman (2004, p, 158)).)

slide-154 This is what the Lidz et al experiment showed.

Note that no one takes this to be evidence for innateness by itself.

slide-155 What is the crucial evidence infants would need to learn the syntactic structure of noun phrases?

This is actually really hard to determine, and an on-going source of debate I think.

But roughly speaking it's utterances where the structure matters for the meaning, utterances like 'You play with this red ball and I'll play with that one'.

slide-156 Lidz et al. (2003) establish this by analysing a large corpus (collection) of conversation involving infants.

slide-157 What can we infer about innateness from this argument?

First, think about what is innate. The fact that knowledge of X is acquired other than by data-driven learning doesn't mean that X is not innate; it just means that something which enables you to learn this is.

Second, think about the function assigned to innateness. That which is innate is supposed to stand in for having the crucial evidence.

This, I think, is the key to thinking about what we *ought* to mean by innateness.

So attributes like being genetically specified are extraneous—they may be typical features of innate things, but they aren't central to the notion.

By contrast, that what is innate is not learned must be constitutive (otherwise that which is innate couldn't stand in for having the crucial evidence)

slide-158 Contrary to what many philosophers (including Stich and Fodor) will tell you ...

slide-159 But they wrote this before Lidz et al. (2003) came out.

slide-160 I asked you this question, but what do I think?

I'd approach it by distinguishing two sub-questions (the second of which has two sub-sub-questions)

**todo: Stress other conceptions and arguments good; start with a project from Spelke and Lee (2012) or from Haun et al. (2010) and you reach a different point!

slide-163 Arguments from the poverty of stimulus are the best way to establish innateness.

The argument concerning syntax we've just been discussing is quite convincing, although if you follow up on the references given in the handout you'll see it's not decisive (as always).

For things other than knowlegde of syntax, the evidence concerning humans is far less clear.

There are, however, quite good cases in nonhuman animals, as many of you know.

So it's not unreasonable to conjecture that learning in the several domains where infants appear to know things early in their first year is innately-primed rather than entirely data-driven.

But, one or two cases aside, there's enough evidence to rule out the converse conjecture.

slide-164 I don't think what is innate is knowledge, nor do I think it's concepts.

But I think there's a good chance that modules are innate (and therefore core knowledge if I'm right to suppose that 'core knowledge' is a term for the fundamental principles describing the operation of a module).

slide-165 On content: I think quite a lot is known about the modules thanks to detailed tests that have little to do directly with controversy about inateness.

slide-166 Why care about whether something is innate? (This isn't suppose to be dismissive.)

slide-167 Here are two reasons why I think we shouldn't worry too much about innateness in trying to understand the origins of mind.

(1) The question about innateness concerns the first transition, whereas I think the second should be our focus (for pragmatic reasons: there's more research).

(2) Discoveries about innately-primed learning make only a relatively modest contribution to understanding the emergence of core knowledge in development. So even when we consider the first transition, it's not obvious that discoveries about innateness are very illuminating, for all their pop-science appeal.

Metaphor: we find a cake in the ruins of Pompeii preserved for a couple of thousand years. We're trying to reconstruct its manufacture. Its good if someone obsesses about where the eggs came from. Did the baker have her own chickens or did she get them from a friend? But knowing where the eggs came from is unlikely to be critical to understanding how the cake was manufactured. We're not finished when we know where the eggs came from, and we're not doomed to fail if we don't know.

slide-168 So let me put the innateness issue aside and get back to what I think matters most …

slide-169 This paradigm allows me to highlight something about core knowledge. I would be a mistake to suppose that there is some core knowledge which later becomes knowledge proper — e.g. the fact that barriers stop solid objects is first core knowledge then later knowledge. The content of the core knowledge is a theory of syntax (let's say). Or, in another case, the content of core knowledge is some principles of object perception. These are things that human adults do not typically know at all, at least not in the sense that they could state the principles. So core knowledge enables us to do things, like anticipate where unseen objects will re-appear or communicate with words. It doesn't seem to be linked directly to the acquisition of concepts.

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