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The inherence heuristic across development: Systematic differences between children's and adults' explanations for everyday facts

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ABSTRACT

The *inherence heuristic* is a basic cognitive process that supplies quick-and-easy answers to what are, in reality, incredibly complex questions about *why* the broad patterns of the world are as they are (Cimpian & Salomon, 2014-a, 2014-b). This explanatory heuristic satisfies the human need to understand, but it is also a source of bias because the heuristic relies too often on the (easily accessible) *inherent features* of the entities in the patterns being explained. Here, we investigated the developmental trajectory of this heuristic. Given that the cognitive resources that help override the typical output of the inherence heuristic are scarce in childhood, we hypothesized that the heuristic's output would be more broadly endorsed by children than by adults. Five experiments involving young children and adults ($N = 480$) provided consistent support for this hypothesis. The first three experiments (Part I) investigated participants' explanations for broad patterns (e.g., fire trucks are red) and suggested that, consistent with our predictions, children were particularly likely to endorse inherence-based explanations. The last two experiments (Part II) investigated two intuitions that accompany the output of the inherence heuristic: namely, that the patterns being explained *cannot be changed* and *are temporally stable*. As predicted, participants' judgments on these dimensions showed the same developmental differences as the explanations investigated in Part I, with children being particularly likely to see patterns as inalterable and temporally stable. The developmental differences found across these five experiments suggest that children start out with a broad reliance on the explanatory output

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of the inherence heuristic, a reliance that narrows in scope to some extent as children develop.
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1. Introduction

The drive to explain and understand is a prominent feature of human psychology (e.g., Gopnik, 1998; Keil, 2006; Lipton, 2004; Lombrozo, 2006; Murphy & Medin, 1985; Ross, 1977; Weiner, 1985). From a young age, children seem eager to go beyond simply learning descriptive facts about the world (e.g., that boys have short hair) to finding the underlying reasons for these facts (e.g., why boys have short hair). The latter, however, is an enormously complex task. The skills necessary to construct accurate explanations for the broad phenomena that characterize our environments require extensive training and access to specialized bodies of empirical and theoretical knowledge. Even a simple fact such as that boys have short hair is, in all likelihood, best explained by multiple converging factors of the sort investigated by historians, sociologists, anthropologists, psychologists, and perhaps even evolutionary biologists. By all accounts, then, most people should be perplexed by questions such as "Why do boys have short hair?" In reality, however, few of us are perplexed. For this, and many other broad patterns, explanatory guesses come to mind quickly and effortlessly. For example, one reason for the short hair might be that boys are very active—long hair would get in the way. To account for the striking ease with which these intuitions arise, as well as for the commonalities in their content, Cimpian and Salomon (2014-a, 2014-b; Cimpian, in press) have recently proposed the existence of an *inherence heuristic*: a cognitive process that leads people to explain the patterns they observe in the world (e.g., boys' short hair) predominantly in terms of the inherent features of their constituents (e.g., boys' inherent restlessness).[1] By supplying explanations for phenomena and patterns that we would otherwise be unable to explain, this process satisfies the human drive to understand. At the same time, however, it also introduces considerable bias into our judgment by leading us to overweigh one class of explanations (those in terms of inherent features).

The goal of the present research was to investigate the *developmental course* of this important explanatory process: Is the inherence heuristic present early in childhood and, if so, does children's reliance on inherence-based explanations expand or contract in scope as they grow older? To motivate these questions, we provide a more detailed account of the inherence heuristic.

1.1. The inherence heuristic

The inherence heuristic is an implicit, intuitive process rather than a deliberate one (e.g., Frederick, 2002). People don't purposely decide to favor inherence-based explanations as a strategy—as a deliberate shortcut to the complex problem of understanding why the world is structured as it is. Rather, these explanations are adopted because they simply come to mind as plausible answers. In this respect, the inherence heuristic is similar to other intuitive heuristics (e.g., Kahneman, 2011; Stanovich & West, 2000). To illustrate, in Kahneman and Tversky's (1973) classic experiments on the representativeness heuristic, most participants found it obvious that Tom W.—with his high intelligence, need for order, and love of sci-fi—was more likely to be studying computer science than social science. Although the Tom W. problem is *objectively* quite complex (because an accurate solution to it must take into account, among other things, the base rates for different fields of study), *subjectively* it appears easy because people rely almost exclusively on the match between Tom W.'s description and their stereotypes about computer scientists (i.e., on how representative Tom W. is of these

[1] In principle, the heuristic applies to particular instances as well, not just patterns. In the case of instances, however, its output may be less reliant on inherent features (for additional discussion, see Cimpian & Salomon, 2014-a, 2014-b). In this paper, we discuss the implications of the inherence heuristic for people's understanding of patterns only.

stereotypes). Both here and in the case of the inherence heuristic, it is as if people inadvertently substitute an easier question for a much harder one (Kahneman, 2011; Kahneman & Frederick, 2002): Instead of "What explains this pattern?" people often end up answering "What inherent features explain this pattern?", just as instead of a question about probabilities they unwittingly answer one about similarity to a stereotype.

To clarify, we use the term *inherent* to refer to any feature that is thought to describe what an object is like—how it is constituted. Inherent features are those that appear to people to characterize a thing "in virtue of the way that thing itself, and nothing else, is" (Lewis, 1983, p. 197). For example, *being round* and *being juicy* are inherent features of an apple, but *being in a bowl* and *being from the neighbor's tree* are not. To put it another way, inherent features are those features of an object that—if changed—would in turn lead to a change in the object itself. Changing an apple's shape would change the apple itself; in contrast, moving it from the bowl to the countertop would not. Inherent properties form a fairly broad set: They can be internal (e.g., apples have carbohydrates) or external (e.g., apples are red), concrete (e.g., apples are sweet) or abstract (e.g., apples are healthy). In sum, this is the sort of information that will dominate the output of the inherence heuristic.[2]

But why is it that inherence-based explanations (as opposed to other types of explanations) come to mind so easily? Why do we have an *inherence* heuristic rather than, say, an extrinsicness heuristic? The prominent role of explanations in terms of inherent features follows from the general principles that govern human reasoning (e.g., Evans, 2006, 2008; Kahneman, 2011; Shah & Oppenheimer, 2008; Stanovich & West, 2000) and memory (e.g., Higgins, 1996; McRae, Cree, Seidenberg, & McNorgan, 2005). When the search for an explanation is triggered (e.g., why do boys have short hair?), the main constituents of the pattern under consideration (e.g., boys, short hair) are salient in one's mind. Salience often translates into presumed relevance (e.g., Higgins, 1996; Sperber & Wilson, 1995)—that is, entities that are salient are also assumed to provide relevant clues for the problem at hand. As a result, when retrieval processes begin to search one's memory for information that may be relevant to generating an explanation, they may oversample the features of these salient focal entities. In particular, because *inherent* features (e.g., boys' energy) are a central part of the representation of these entities in semantic memory (e.g., McRae & Jones, 2013; McRae et al., 2005; Rosch & Mervis, 1975), and are thus *easily accessible* to retrieval processes, these properties will often dominate the pool of facts retrieved for the purpose of generating an explanation. In turn, this imbalance has important consequences for downstream processing: When the cognitive system goes on to assemble an explanation out of the information at its disposal (that is, the information activated in the previous step), its output will be correspondingly skewed towards explanatory intuitions that appeal to the inherent features of the relevant focal entities (e.g., short hair is perfect for boys' active nature).

Despite the shortcuts built into this heuristic process, the facile intuitions it generates are generally adopted without much scrutiny, as is the case with the output of other heuristic processes: Extensive evidence suggests that humans take the path of least cognitive effort whenever possible, routinely "satisficing" rather than striving for accuracy (Evans, 2006, 2008; see also Shah & Oppenheimer, 2008; Simon, 1982; Stanovich, 2011). Because people tend to settle for the first plausible guess that comes to mind, and because these first guesses arise from processes that are biased toward retrieving and using inherent facts, people's final judgments end up correspondingly overweighing inherent factors.

1.2. Developmental predictions

Having described the process underlying the inherence heuristic, we now go on to spell out the developmental predictions of this account. Our first prediction is that the heuristic should also

[2] We should note that we are operating with a *psychological* notion of inherence. Philosophers have long debated whether the intrinsic/extrinsic distinction is in fact metaphysically coherent (e.g., Weatherson & Marshall, 2013): For example, is *being round* truly inherent, or is it extrinsic because it depends on the shape of the space in which the relevant object is embedded? Similarly, is *being red* perhaps extrinsic rather than inherent because it depends on the existence of psychological agents with a certain type of perceptual apparatus? Although these are interesting metaphysical questions, the notion of an inherent feature nevertheless seems *psychologically* meaningful and coherent, and is easily applied in many everyday circumstances (e.g., few people would doubt that *being round* is inherent in the relevant object).

influence young children's reasoning. We base this prediction on the fact that the cognitive processes that give rise to inherent explanations[3] are not peculiar to adult cognition. Contrary to the claims of Jean Piaget and other stage theorists (e.g., Piaget, 1952; Piaget & Inhelder, 1969; see also Flavell, 1963), the cognitive system undergoes few qualitative changes over the course of development, with most of development being quantitative and gradual (e.g., Case, Kurland, & Goldberg, 1982; Kail, 1991; Williams, Ponesse, Schachar, Logan, & Tannock, 1999). Thus, if the process by which adults retrieve relevant knowledge for the purpose of generating explanations displays certain quirks (e.g., a tendency to oversample easily-accessible inherent features), it seems plausible that the same quirks would characterize children's knowledge retrieval as well. Furthermore, if these quirks lead adults to rely on inherent features in their intuitive explanations more often than is warranted, the same might also be true of children. These considerations motivate our first prediction—namely, that children's reasoning should show the hallmarks of the inherence heuristic.

Our second prediction concerns the extent of the heuristic's influence across development: Are inherent explanations more prevalent in children's reasoning or in adults'? In thinking about this question, it may be helpful to first consider some of the factors that could enable an individual to block or revise the output of the inherence heuristic. The availability of these factors at different ages will then inform our predictions regarding the developmental course of the heuristic's influence. Assuming that the heuristic process operates as described in the previous section, an individual's ability to overcome the lure of inherent explanations will likely increase with the availability of resources such as the following: (1) richer, and more easily accessible, knowledge of extrinsic factors (e.g., historical events, social conventions) that are relevant to the pattern being explained; (2) greater cognitive abilities, which may enable a wider, more varied assortment of facts to be retrieved from memory and integrated into a final explanation; and (3) greater cognitive control, which may counteract the reflexive tendency to adopt the first plausible intuition that pops into one's mind (and may correspondingly increase the level of scrutiny to which these first intuitions are subject). Recent research has begun to document the importance of these factors: For example, although adults exhibit a strong baseline preference for inherent explanations, this preference is magnified when cognitive resources are low, either temporarily (when attention is diverted to a secondary task) or chronically (as measured by a test of fluid intelligence) (Cimpian & Salomon, 2014-a; Salomon & Cimpian, in preparation, 2014). Similarly, inherent explanations are particularly appealing when the motivation to engage in effortful thought, and thus to exert control over one's judgments, is low (Salomon & Cimpian, 2014).

In light of the fact that the aforementioned cognitive resources are scarcer in children relative to adults (e.g., Akshoomoff et al., 2013; Carlozzi, Tulsky, Kail, & Beaumont, 2013; Kail, 1991; Williams et al., 1999; Zelazo et al., 2013), our prediction with respect to development is that children should interpret *more* of the patterns they observe in the world through the lens of the inherence heuristic than adults do. That is, we predict that, while the heuristic guides much of adults' understanding of the regularities they detect around them, it should be even more influential in children's thinking.

1.3. Prior research

Although no previous studies have directly investigated the developmental course of the inherence heuristic, the extant developmental literature does provide some indirect support for our hypotheses. For example, several studies from our lab suggest that children as young as 4 tend to interpret patterns in inherent terms across a range of ontological domains (artifacts: Cimpian & Cadena, 2010; social groups: Cimpian & Erickson, 2012; Cimpian & Markman, 2011; natural kinds: Cimpian & Markman, 2009). When told, say, that boys are good at a game called "gorp," preschoolers tend to explain this fact in terms of the inherent features of boys (e.g., they are smart) rather than factors external to boys (e.g., their parents taught them; Cimpian & Markman, 2011). This bias

[3] We use the term *inherent explanations* to refer to explanations that appeal to inherent features. We do not mean to imply that the explanations are somehow inherent in the things explained.

toward inherent explanations was not as prominent when children were asked to explain the same facts in the context of a single individual (e.g., why a particular boy is good at "gorp"). Extrinsic information (e.g., about prior history or circumstances) is more naturally represented and stored at the level of specific individuals than at the level of entire kinds; as a result, this information may also be more likely to be retrieved when explaining observations concerning individuals, which would reduce the reliance on inherence.

There is also some indirect evidence for our second prediction, namely that the scope of the inherence heuristic narrows with age. Specifically, a few studies have suggested that young children are less likely than older children and adults to believe that current patterns can be changed—even when these patterns are in reality mutable social conventions such as word–object pairings or rules of etiquette (e.g., Lockhart, Abrahams, & Osherson, 1977; Osherson & Markman, 1975; Piaget, 1929/1967). This developmental trend is consistent with the predictions of our argument because explaining a pattern in terms of the inherent features of its constituents easily licenses the further inference that this pattern cannot be otherwise. If, for example, boys' short hair is the perfect accompaniment to their high energy, then it would seem unwise to change this hairstyle. Thus, the changes in children's beliefs about whether societal patterns can be changed may be linked to changes in children's explanations for these patterns.

1.4. Overview of experiments

To review, we predicted (1) that even children would exhibit a tendency to explain observed regularities in inherent terms, and (2) that these inherent explanations would in fact be more prevalent in children's than in adults' thinking. These hypotheses were tested across five experiments, organized into two parts.

The first three experiments (Part I) compared how children and adults make sense of observed patterns. Because the verbal abilities of young children and adults are so mismatched, we opted for an explanation evaluation (rather than production) paradigm. That is, participants were simply asked to judge whether the inherent and extrinsic explanations provided to them were right or wrong. Although the inherence heuristic proposal concerns most directly how people *generate* explanations, it can naturally be extended to predict a bias toward inherence in evaluation as well: Inherent explanations should be evaluated more positively than extrinsic ones because they better match how, according to our proposal, participants spontaneously make sense of the relevant observations.

The last two experiments (Part II) investigated developmental differences in intuitions that follow from inherent explanations: specifically, (1) that observed patterns are inalterable (Experiment 4), and (2) that observed patterns are temporally stable—that is, that they have always been and will always be exactly as they are now (Experiment 5).

In terms of age, the children in our studies were, on average, 5 years old. We judged this to be the youngest age at which children would possess the language comprehension skills and the metacognitive abilities required to reliably evaluate the explanations in our tasks. We did, however, sample broadly around this average age, including many children as young as 4 or as old as 7. This relatively wide age range allowed us to look for developmental differences in inherent thinking *within* the child sample (see the supplemental analyses in Section 4). Nevertheless, our main analyses treated children as a single group and compared their responses with adults' responses.

Together, the five studies reported here provided consistent support for our hypotheses, highlighting the inherence heuristic as a powerful force in cognitive development.

2. Part I: Investigating children's and adults' explanations for observed patterns

In Part I, we asked children and adults to evaluate two types of explanations for observed patterns: *inherent* explanations and *extrinsic* explanations. The inherent explanations were formulated to be relatively general rather than specific. In Experiments 1 and 2, for example, these explanations took the form of a global appeal to the relevant objects' constitution (e.g., fire trucks are red "just because they are fire trucks"[4]). The generality of these inherent explanations offered several advantages. First, and most importantly, a general explanation can serve as a catch-all for the many different ways people might spontaneously make sense of the relevant patterns. Because individuals might rely on different inherent facts to explain these patterns, an inherent explanation formulated at a general level can encompass, or capture, the various explanations that individual participants might come up with on their own. Second, general explanations may also be more easily understood by a wider range of participants regardless of their prior knowledge of the topics we asked about. Third, since explanations that are more general are also applicable across a wider range of patterns, this feature of the stimulus explanations enabled us to keep their wording uniform across our items and thus minimize random variability in responses. These inherent explanations were compared with explanations that appealed to extrinsic factors—mainly social conventions—and that were designed to be similarly general (e.g., fire trucks are red "just because people thought it might be a nice idea").

Both of these types of explanations were evaluated for two types of patterns. The first type consisted of patterns that are in reality due mostly to social conventions (e.g., fire trucks are red). For these *conventional* patterns, we expect strong developmental changes in endorsement of inherent and extrinsic explanations. Specifically, children should be particularly likely to see these patterns as being due to the inherent natures of the things involved rather than to social conventions or historical events. Relative to adults, for example, children may have less access to relevant facts with which to build extrinsic explanations or revise their initial inherence-based intuitions. Due to their more limited cognitive capacities, children may also retrieve less numerous, and less diverse, facts from memory when generating explanations, which may further increase the chances that they will rely only on the most easily accessible (and mostly inherent) information when constructing their explanations. (To clarify, however, the claim here is not that children are the only ones who rely on the inherence heuristic and that adults are free from its influence. Rather, we are proposing that adults may just be less indiscriminate than children in their reliance on inherent explanations.)

The conventional patterns just described were compared to a set of *control* patterns (e.g., fire trucks have hoses). These control patterns were chosen because they are in fact better explained by the inherent natures of the things involved rather than being largely a matter of social convention. As a result, we do not expect to see developmental changes in endorsement of inherent and extrinsic explanations for these control patterns: Inherent explanations should be endorsed more often than extrinsic ones by both children and adults.

Thus, the design of the first three experiments can be summarized as follows: Age (children vs. adults) × Explanation (inherent vs. extrinsic) × Pattern (conventional vs. control). In the context of this design, the two main predictions of our argument (namely, that children should be subject to the inherence heuristic, and that the scope of this heuristic should narrow with development) translate into a prediction for a three-way interaction: For the *conventional* patterns (e.g., fire trucks are red), we predicted that children would display a stronger preference for inherent over extrinsic explanations relative to adults, whose greater cognitive resources and richer knowledge base should make them more circumspect about attributing these patterns to inherent features. This development would result in a significant two-way Age × Explanation interaction. In contrast, for the *control* patterns (e.g., fire trucks have hoses), children and adults should be similar in their preference for inherent over extrinsic explanations, resulting in a weaker or non-significant Age × Explanation interaction.

2.1. Experiment 1

2.1.1. Method

2.1.1.1. Participants. The participants were 48 children (M_{age} = 5.91 years, SD = 1.28; 24 girls and 24 boys) and 48 adults (20 women and 28 men). Children were recruited in a small Midwestern city. They were socioeconomically diverse, and a majority were European American, although demographic

[4] Prasada and his colleagues have termed explanations of this sort *formal* explanations (Prasada & Dillingham, 2006, 2009; Prasada, Khemlani, Leslie, & Glucksberg, 2013). We discuss the relation between our account and Prasada's in Section 5.2.2.

information was not collected formally. One additional child was tested but excluded from the sample because she did not complete the task. The adults were recruited from two different sources. Half of them ($n = 24$) were recruited from the undergraduate subject pool of a large public university and received course credit for their participation. These participants were tested in person by a researcher. The other half of the adult participants ($n = 24$) were recruited through Amazon's Mechanical Turk platform and were paid $0.75 for their participation. Data collected via Mechanical Turk are generally reliable (e.g., Buhrmester, Kwang, & Gosling, 2011). Nevertheless, as a means of ensuring data quality, we embedded several catch questions (e.g., ''Please click on the number two below'') among the test questions to identify inattentive participants. In this and all subsequent experiments, we excluded participants who missed any of these catch questions. In the present experiment, three participants (beyond the 24 retained for analysis) were excluded for this reason. Finally, note that Mechanical Turk participants were prevented from participating in more than one of the studies reported here with the use of an external tool designed expressly for this purpose (TurkGate; Goldin & Darlow, 2013).

2.1.1.2. Materials.

2.1.1.2.1. Patterns. Each participant was asked about eight patterns, four *conventional* ones (e.g., fire trucks are red) and four *control* ones (e.g., fire trucks have hoses) (see Table 1 for full list and Appendix A.1.1 for norming data that validates our assignment of these patterns to the conventional vs. the control set). The two types of patterns were matched with respect to the objects they featured (e.g., fire trucks were featured in one pattern of each type). The conventional and control patterns were presented to participants as separate blocks whose order was counterbalanced.

2.1.1.2.2. Explanations. Participants were asked to evaluate both an inherent and an extrinsic explanation for each of the eight patterns. As explained above, the inherent explanations framed each pattern as a consequence of the inherent nature of the relevant objects (e.g., fire trucks are red ''just because they are fire trucks''). In contrast, the extrinsic explanations framed each pattern as a social convention (e.g., fire trucks are red ''just because people thought it might be a nice idea''). A separate study validated our assumption that the inherent explanations used as stimuli here were more likely to capture the output of the inherence heuristic than the extrinsic explanations were (see Appendix A.1.2).

All inherent and extrinsic explanations followed the format of the explanations in the examples above. The order of these explanations was constant across the eight trials for any one participant but was counterbalanced across participants.

2.1.1.3. Procedure. Children were tested individually in a quiet room in our lab or in their school. Below, we describe the details of the procedure used with our child participants. Adults were administered either a pen-and-paper version of this task (the undergraduate participants) or an online survey version of it, designed in Qualtrics (the Mechanical Turk participants).

The experimenter began each trial by telling children that she had been ''talking to some friends'' about why something is the case (e.g., why fire trucks are red). The experimenter then said, ''Here are two reasons that my friends came up with. I wanted to know what you think of these reasons,'' and proceeded to elicit children's opinion about the inherent and extrinsic explanations (in counterbalanced

Table 1
The conventional and control patterns used in Experiments 1–3.

Expt.	Conventional patterns	Control patterns
1 and 2	Boys have short hair	Boys grow up to be daddies
	Doctors wear white coats	Doctors give medicine
	Fire trucks are red	Fire trucks have hoses
	Soap smells nice	Soap cleans your hands
3	Baseball players wear long socks	Baseball players run fast
	Police officers have stars on their badges	Police officers wear uniforms
	Stop signs are red	Stop signs are tall
	School buses are yellow	School buses have windows

order). For example, she said, "Okay, so one person said that fire trucks are red just because they are fire trucks" (inherent explanation). To elaborate and clarify the meaning of this explanation, she also added, "And fire trucks have to be red." If children think that the patterns they observe in the world emerge as a consequence of the inherent features of their constituents, they may also infer that these patterns could not have been otherwise (Cimpian & Salomon, 2014-a)—thus, fire trucks have to be red, boys have to have short hair, and so on.

Next, the experimenter asked children to evaluate this explanation. The evaluation question referred only to the main explanation (e.g., "just because they are fire trucks") and omitted the "have to" elaboration. For example, the experimenter asked, "Is this person *right* or *not right* to think that fire trucks are red just because they are fire trucks?" To facilitate children's responses, this question was accompanied by pictures of "thumbs up" and "thumbs down" that the experimenter pointed to while she said "right" and "not right," respectively. Children could thus respond non-verbally by pointing to one of these pictures.

After children answered the initial right/not right question, the experimenter asked a follow-up question designed to provide a more fine-grained measure of children's evaluation: "Are they a *little* [not] right, or are they *really* [not] right?" Children's responses were assigned numerical values ranging from 1 ("really not right") to 4 ("really right").

Children's evaluation of the extrinsic explanations was elicited in a similar manner. For example, children heard,

> Okay, now another person had a different thought. This person said that fire trucks are red just because people thought it might be a nice idea. But fire trucks don't really have to be red. Is this person right or not right to think that fire trucks are red just because people thought it might be a nice idea?

The same follow-up question was asked after the right/not right question, and children's answers were again converted into a numerical value ranging from 1 to 4 that indicated their agreement with the explanation.

At the end of the session, children were thanked for their participation and praised for their responses. They also received a small reward.

2.1.1.4. Data analysis. The dependent variables (namely, participants' agreement with the inherent and extrinsic explanations for the conventional and control patterns) were non-normally distributed (Shapiro–Wilk tests, *p*s < .001), and some were also heteroscedastic across the age groups (Levene's tests, *p*s < .005). Thus, we analyzed the data with a statistical procedure that does not require that these parametric assumptions be met: namely, a repeated-measures ordinal logistic regression (OLR) computed via the Generalized Estimating Equations command in SPSS (for other examples of this analysis, see Cimpian & Erickson, 2012; Cimpian & Markman, 2011). Follow-up analyses were performed with non-parametric Wilcoxon signed-rank tests for all experiments in Part I. Finally, in keeping with the non-parametric nature of the analyses, we report—in addition to means—the percentages of participants who preferred the inherent over the extrinsic explanations ("I > E responders") or vice versa ("E > I responders") for a particular pattern type.

2.1.2. Results and discussion

Our key prediction was of a three-way interaction between Pattern, Explanation, and Age: For the conventional patterns (e.g., fire trucks are red), we expected that children would be more likely than adults to appeal to inherent (but not extrinsic) explanations, leading to a significant Explanation × Age interaction. For the control patterns (e.g., fire trucks have hoses), however, both children and adults should prefer the inherent explanations, leading to a weak or non-significant Explanation × Age interaction.

Table 2 displays the average agreement ratings for all cells of the Pattern × Explanation × Age design, and Table 3 displays the full output of the OLR. Most pertinent to our argument, the OLR revealed the predicted three-way interaction, Wald $\chi^2(1) = 24.96$, $p < .001$. To explore the source of this interaction, we examined the two-way Explanation × Age interactions separately for the conventional and the control patterns.

Table 2
Average agreement ratings by experiment, age group, explanation type, and pattern type (standard deviations in parentheses).

Expt.	Age group	Explanation type	Pattern type	
			Conventional patterns	Control patterns
1	Children	Inherent	2.78 (0.98)	3.05 (0.88)
		Extrinsic	2.47 (0.95)	2.39 (1.06)
	Adults	Inherent	1.91 (0.67)	2.67 (0.73)
		Extrinsic	3.07 (0.65)	2.08 (0.68)
2	Children	Inherent	2.83 (0.97)	3.08 (0.83)
		Extrinsic	2.63 (1.00)	2.40 (0.97)
	Adults	Inherent	2.08 (0.86)	2.60 (0.89)
		Extrinsic	2.74 (0.82)	2.01 (0.83)
3	Children	Inherent	3.14 (0.92)	3.16 (0.81)
		Extrinsic	2.67 (0.95)	2.62 (0.99)
	Adults	Inherent	2.76 (0.61)	3.28 (0.68)
		Extrinsic	2.61 (0.83)	2.11 (0.78)

Note. The ratings could range from 1 = "really not right" to 4 = "really right."

Table 3
Summary of OLR results across Experiments 1–3.

Effect	Experiment 1		Experiment 2		Experiment 3	
	Wald χ^2	p	Wald χ^2	p	Wald χ^2	p
Explanation	1.58	.208	4.20*	.041	37.05***	<.001
Pattern	0.20	.655	0.45	.503	0.01	.923
Age	4.95*	.026	10.73**	.001	4.14*	.042
Explanation × Pattern	51.53***	<.001	35.12***	<.001	19.43***	<.001
Explanation × Age	14.95***	<.001	5.28*	.022	0.11	.739
Pattern × Age	1.68	.194	0.60	.439	0.57	.449
Explanation × Pattern × Age	**24.96***	**<.001**	**7.77**	**.005**	**16.81***	**<.001**

Note. The degrees of freedom for all main effects and interactions equal 1. The values bolded pertain to the crucial three-way interaction between Explanation, Pattern, and Age.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Consistent with our account, the data for the conventional patterns showed a significant Explanation × Age interaction, Wald $\chi^2(1) = 34.24$, $p < .001$ (see Table 4 for the full output of pattern-specific OLRs). This interaction emerged from the predicted asymmetry between children and adults in their reliance on inherent explanations: Whereas adults were significantly more likely to agree with the extrinsic explanations (6.3% I > E vs. 87.5% E > I responders, Wilcoxon $p < .001$), children showed a slight preference for the inherent explanations instead (43.8% I > E vs. 31.3% E > I responders, Wilcoxon $p = .190$; see Table 2 for means).

Also as predicted, the data for the control patterns revealed no significant Explanation × Age interaction, Wald $\chi^2(1) = 0.54$, $p = .461$. Here, inherent explanations were favored over extrinsic explanations both by adults (68.8% I > E vs. 18.8% E > I responders, Wilcoxon $p < .001$) and by children (60.4% I > E vs. 20.8% E > I responders, Wilcoxon $p < .001$).

In sum, the results of this study were consistent with the predictions of the inherence heuristic account. First, when making sense of the regularities that structure their world—even ones that are in reality due largely to extrinsic (conventional, historical, etc.) factors—children are prone to understand these regularities as a byproduct of the nature or constitution of the objects that make them up. Second, this reliance on inherent explanations seems to narrow with development.

Table 4
Summary of OLR results investigating the Explanation × Age interaction separately by pattern type, across Experiments 1–3.

Pattern type	Effect	Experiment 1		Experiment 2		Experiment 3	
		Wald χ^2	*p*	Wald χ^2	*p*	Wald χ^2	*p*
Conventional	Explanation	9.29**	.002	2.45	.118	11.37***	<.001
	Age	1.71	.191	5.72*	.017	4.26*	.039
	Explanation × Age	**34.24******	**<.001**	**10.75****	**.001**	**4.42***	**.036**
Control	Explanation	25.29***	<.001	27.64***	<.001	46.37***	<.001
	Age	5.93*	.015	10.16**	.001	2.37	.124
	Explanation × Age	**0.54**	**.461**	**0.27**	**.603**	**6.59***	**.010**

Note. The degrees of freedom for all main effects and interactions equal 1. The values bolded pertain to the crucial two-way interaction between Explanation and Age.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

2.2. Experiment 2

In the previous study, the explanations provided to participants were accompanied by an additional statement about whether the relevant pattern had to be as it is (e.g., "fire trucks [don't] have to be red"). We included this statement as a way of elaborating the meaning of the explanations. For example, if fire trucks are thought to be red because of some inherent feature of fire trucks and/or the color red, it is unlikely that fire trucks could have been any other color (that is, they had to be red). However, the presence of this extra statement also creates some uncertainty as to the basis for participants' responses in Experiment 1. Specifically, it is possible that their agreement or disagreement was directed at this statement rather than at the explanation itself (e.g., "just because they are fire trucks"). Note, however, that the question addressed to participants in Experiment 1 included *only* the main explanation (and omitted the extra "have to" statement), so this alternative possibility is somewhat remote. Nevertheless, for a more precise test of our proposal, in Experiment 2 we omitted the "have to" elaboration altogether. The prediction was that we would replicate the results of Experiment 1.

Our second major goal in this study was to test whether the predicted results are robust to variations in the surface content of the explanations. Thus, we changed the wording of the extrinsic explanations from "just because people thought it might be a nice idea" to "just because people wanted it that way." This new phrasing is more broadly applicable than the phrasing used in Experiment 1, which may in turn make the extrinsic explanations stronger foils for the inherent ones. We again expected to replicate the results of Experiment 1.

2.2.1. Method

2.2.1.1. Participants. The participants were 48 children (M_{age} = 5.97 years, *SD* = 1.14; 24 girls and 24 boys) and 48 adults (25 women and 23 men). Participants in this and subsequent studies were similar in their demographic characteristics to the participants in Experiment 1. One additional child was tested but excluded from the sample because he did not complete the task. Two additional Mechanical Turk participants were tested but excluded because they failed the attention checks.

2.2.1.2. Materials and procedure. The materials and procedure were identical to those of Experiment 1, except that (as explained above) we broadened the wording of the extrinsic explanations and replaced the "[don't] have to" elaborations with ones that were simply restatements of the explanations themselves (e.g., "That's just how fire trucks are" [inherent] and "That's just what people decided" [extrinsic]).

2.2.2. Results and discussion

Replicating the results of Experiment 1, the OLR uncovered a significant three-way Pattern × Explanation × Age interaction, Wald $\chi^2(1) = 7.77$, $p = .005$ (see Table 3 for full OLR output). Moreover, the source of this interaction was the same as in Experiment 1 (see Table 2 for means). When participants were asked about *conventional* patterns, their responses showed a significant two-way Explanation × Age interaction, Wald $\chi^2(1) = 10.75$, $p = .001$ (see Table 4 for the full output of pattern-specific OLRs). As predicted, adults judged the extrinsic explanations to be more adequate than the extrinsic ones (16.7% I > E vs. 62.5% E > I responders, Wilcoxon $p < .001$), whereas children were somewhat more partial to the inherent explanations instead (50.0% I > E vs. 33.3% E > I responders, Wilcoxon $p = .302$). Also consistent with our predictions, the data for the *control* patterns showed no significant Explanation × Age interaction, Wald $\chi^2(1) = 0.27$, $p = .603$. Both children (64.6% I > E vs. 20.8% E > I responders, Wilcoxon $p < .001$) and adults (66.7% I > E vs. 16.7% E > I responders, Wilcoxon $p < .001$) favored inherent explanations to approximately the same extent.

To summarize, in Experiment 2 we eliminated some of the extraneous information that could have swayed children's responses in Experiment 1 (specifically, the information about whether the patterns had to be in place), and we also varied the surface form of the explanations that children were asked to evaluate. Nevertheless, the results replicated the results of Experiment 1. That is, we found similar developmental differences, with a transition to less inherence-based thinking for the conventional but not the control patterns.

2.3. Experiment 3

In Experiment 3, we introduced two major changes to the stimuli. First, we used a different set of eight patterns (see Table 1, bottom). This modification afforded a further test of the claim that the inherence heuristic applies broadly. Second, we changed the content of the inherent explanations. According to the inherence heuristic account, the heuristic seeks to assemble the information retrieved from memory into an explanation as quickly as possible and with minimal effort (Cimpian & Salomon, 2014-a, 2014-b). As a result, the heuristic is likely to capitalize on any available means of generating an easy explanation. In other words, the heuristic is fairly unselective in terms of the explanatory frameworks it uses; causal notions are not the only type of explanatory "glue" it relies on. To capture the heuristic's promiscuity in this respect, we asked participants to evaluate inherent explanations that were value-based—specifically, ones that appealed to considerations of optimality (e.g., police officers have stars on their badges because stars are what *works best* for police officers' badges; school buses are yellow because yellow is what *works best* for school buses). Note that, although these explanations took a different form than those in the first two studies, they were nevertheless formulated at a similarly general level, such that they did not include mention of specific inherent features. Our prediction was that we would replicate the results of Experiments 1 and 2.

2.3.1. Method

2.3.1.1. Participants. The participants were 48 children ($M_{age} = 6.06$ years, $SD = 0.96$; 24 girls and 24 boys) and 48 adults (24 women and 24 men). Two additional children were tested but excluded from the sample because they did not complete the task. One additional Mechanical Turk participant was tested but excluded because he failed the attention checks, and another because she gave the same answer ("really agree") to all 16 questions and later, in debriefing, commented that she probably misunderstood the instructions.

2.3.1.2. Materials.

2.3.1.2.1. Patterns. We replaced the patterns used in the first two studies with an entirely different set of eight patterns (see bottom of Table 1 for full list, and Appendix A.2.1 for data validating our assignment of these patterns to the conventional vs. the control set). Since the new patterns (e.g., the stars on police officers' badges) may be somewhat less common in children's everyday lives than the patterns used in the previous studies, we tested a separate sample of children to verify that the new patterns are in fact familiar to children this age. The data reported in Appendix A.2.2 confirmed that they are. (If the patterns had been unfamiliar, children would have had fewer opportunities to make sense of them via the inherence heuristic.)

2.3.1.2.2. Explanations. We replaced the inherent explanations used in Experiments 1 and 2 with ones formulated in terms of optimality ("works best"). A separate norming study, described in

Appendix A.2.3, validated the link between these new explanations and the inherence heuristic account. Two other, minor, changes were also made to the wording of the explanations. First, we no longer included elaborations of any sort. Second, the wording of the extrinsic explanations was varied once again (e.g., school buses are yellow "just because that's what some people decided a long time ago"). After these changes, the inherent and extrinsic explanations were worded as in the following examples:

> *Inherent:* Okay, so one person said that school buses are yellow because yellow is what works best for school buses. Is this person *right* or *not right* to think that school buses are yellow because yellow is what works best for them?
>
> *Extrinsic:* Okay, now another person had a different thought. This person said that school buses are yellow just because that's what some people decided a long time ago. Is this person *right* or *not right* to think that school buses are yellow just because that's what some people decided a long time ago?

2.3.1.3. Procedure. The procedure was identical to that of Experiments 1 and 2, with two minor exceptions. First, we showed participants pictures that illustrated the patterns they were asked about (e.g., a yellow school bus, a police badge with a star on it). We reasoned that showing children these pictures would jog their memory of the relevant patterns and would thus call up any previous inferences they had made about their source. The pictures were brought out when the experimenter first mentioned the pattern on each trial and were then put away before the experimenter started asking her questions. Second, we added a non-verbal response option to the follow-up question asked after children indicated whether an explanation was "right" or "not right." That is, we allowed children to point to one of two pictures instead of having to say "a little [not] right" or "really [not] right." If the children responded "right," the experimenter asked the follow-up question using a scale that consisted of one small and one large "thumbs up" picture (corresponding to "a little right" and "really right," respectively); both were green in color. Small and large "thumbs down" pictures were used to follow up on a "not right" response; both were red in color.

2.3.2. Results and discussion

As before, our main prediction is of a three-way Pattern × Explanation × Age interaction. The OLR performed on the data from Experiment 3 revealed this predicted interaction, Wald $\chi^2(1) = 16.81$, $p < .001$ (see Table 3 for full OLR output). Next, we examined the conventional and control patterns separately to determine whether, as before, this interaction stemmed from (1) a greater reliance on inherence in children's than in adults' explanations for the conventional patterns, combined with (2) a developmentally stable endorsement of inherent explanations for the control patterns.

In line with our proposal, the data for the conventional patterns showed a significant Explanation × Age interaction, Wald $\chi^2(1) = 4.42$, $p = .036$ (see Table 4 for the full output of pattern-specific OLRs). Although children made sense of conventional patterns such as the color of school buses predominantly in inherent terms (56.3% I > E vs. 10.4% E > I responders, Wilcoxon $p = .001$), adults were considerably more ambivalent (43.8% I > E vs. 50.0% E > I responders, Wilcoxon $p = .369$).

In sharp contrast, both children (62.5% I > E vs. 16.7% E > I responders, Wilcoxon $p < .001$) and adults (83.3% I > E vs. 8.3% E > I responders, Wilcoxon $p < .001$) reasoned that control patterns such as that school buses have windows are better accounted for by inherent explanations. However, because children's data were noisier than those of adults, the Explanation × Age interaction was actually significant, Wald $\chi^2(1) = 6.59$, $p = .010$. In general, the task of evaluating explanations is both linguistically and metacognitively complex; both of these aspects are likely to pose difficulties to children, which may occasionally make the control item differences appear less sharp for children than for adults.

2.4. Conclusions for Part I

We proposed that (1) from an early age, children make sense of the patterns observed in the world via a heuristic process that leads them to overweigh explanations in terms inherent factors (that is, factors that pertain to the constitution of the objects in the relevant patterns), and that (2) with development, children revise some of these intuitions, leading to a narrowing of the range of phenomena explained in inherent terms. The three studies in Part I, which directly assessed children's and adults' endorsement of inherent and extrinsic explanations, provided support for these two claims.

However, because children generally preferred the inherent explanations across the board in these studies, one might worry that this preference does not truly stem from how children reason about the world but rather from some superficial feature of our design (e.g., the wording of the explanations). If children's behavior was driven by task demands rather than their explanatory intuitions, then one might expect them to have rated the inherent explanations equally positively (and the extrinsic explanations equally negatively) no matter whether these explanations were provided for the conventional patterns or the control patterns. In contrast, if children's responses in these studies tracked their explanatory intuitions, then one might expect children to have flexibly differentiated between the two types of patterns, rating the inherent explanations as being more appropriate for the control (vs. the conventional) patterns and the extrinsic explanations as being more appropriate for the conventional (vs. the control) patterns.

To tease apart these possibilities, we submitted children's data from Experiments 1–3 to an Experiment × Pattern × Explanation OLR. This analysis revealed that children's overall preference for the inherent over the extrinsic explanations, Wald $\chi^2(1) = 25.47$, $p < .001$, was indeed qualified by the Pattern × Explanation interaction one would expect to see if our task were tapping into children's explanatory reasoning rather than their compliance with task demands, Wald $\chi^2(1) = 6.73$, $p = .009$. Sensibly, children rated the inherent explanations to be more adequate for the control ($M = 3.10$) than the conventional ($M = 2.92$) items, Wilcoxon $p = .005$. Equally sensibly, children thought that the extrinsic explanations were more suited for the conventional ($M = 2.59$) than the control ($M = 2.47$) items, Wilcoxon $p = .077$. We should also note that this Pattern × Explanation interaction did not differ significantly across the three experiments, as evidenced by the non-significant Experiment × Pattern × Explanation interaction, Wald $\chi^2(2) = 3.69$, $p = .158$. In sum, this analysis suggests that children's endorsement of the inherence-based explanations in our studies genuinely speaks to how they make sense of the world.

3. Part II: Investigating intuitions that accompany inherence-based explanations

The studies in Part II were designed to provide converging evidence for our hypotheses concerning differences between children and adults in their reliance on the typical (inherence-based) output of the inherence heuristic. In these studies, we investigated two inferences that follow from inherent explanations: namely, inferences about the *inalterability* of observed patterns and inferences about their *temporal stability*. If a pattern is explained exclusively via the inherent features of its constituents, it is not much of a leap to infer that the pattern has to be, and has always been, exactly as it currently is.

If these inferences accompany the typical output of the inherence heuristic, as we argue, then they should show the same developmental differences as the inherent explanations examined in Part I. Experiment 4 tested this prediction with respect to people's intuitions about the inalterability of observed patterns, whereas Experiment 5 explored intuitions about temporal stability.

3.1. Experiment 4

3.1.1. Method

3.1.1.1. Participants. The participants were 48 children ($M_{age} = 5.79$ years, $SD = 1.25$; 24 girls and 24 boys) and 48 adults (26 women and 22 men). One additional child was tested but excluded from the sample because she did not complete the task. One additional Mechanical Turk participant was tested but excluded because she failed the attention checks.

3.1.1.2. Materials. To further highlight the generalizability of our results, we used yet another set of four conventional patterns (e.g., "Coins are round") and four control patterns (e.g., "Pillows are soft")

Table 5
The conventional and control patterns used in Experiments 4 and 5.

Conventional patterns	Control patterns
Birthday cakes have candles	Bubblegum is chewy
Coins are round	Fire alarms are loud
Money is green	Pillows are soft
School buses are yellow	Wheels are round

(see Table 5 for full list, and Appendix A.3.1 for norming data). In this study, however, the conventional and control patterns did not form matched pairs (e.g., there was no control pattern about coins); rather, the patterns all involved different objects. This change enabled us to include a greater variety of patterns in our stimuli than was possible before. The four patterns of each type were presented as a block, and the order of the conventional and control blocks was counterbalanced.

3.1.1.3. Procedure. Obviously, patterns as broad as whether *coins are round* would be, practically speaking, very difficult to change. Thus, participants might hesitate to say that such patterns are changeable even if they fully understood the conventional nature of these patterns. To avoid this difficulty, we asked participants whether it would be okay to change a pattern *assuming that the social consensus favored such a change*. This consensus information was intended to minimize practical concerns, allowing participants to respond on the basis of whether they understood the relevant pattern to be due to inherent or extrinsic–historical factors. For example, the question concerning the shape of coins was worded as follows,

> Imagine if people wanted coins to be a different shape, and everyone agreed that they wanted coins to be a different shape. Would it be okay to make a change so that coins are not round, or would it not be okay?

In children's version of the procedure, if a child said it was "not okay" to make a change, the experimenter asked a follow-up question to gauge how strongly the child felt about the inalterability of the pattern. For example, the experimenter asked, "Would it be *sort of* not okay, not okay, or *really* not okay to make a change to the shape of coins?" Children's responses were assigned numerical values ranging from 1 ("okay" to make a change) to 4 ("really not okay"). Thus, higher values indicated stronger intuitions about the inalterability of observed patterns. In adults' version of the procedure, the participants were simply asked to indicate in their surveys whether the change would be "really not okay," "not okay," "sort of not okay," or "okay." These responses were assigned the same numerical values as children's responses.[5]

Participants were also asked to justify their responses on each trial (e.g., "Why do you think it is [not] okay to make a change so that coins are not round?"). Our main goal in eliciting these justifications was to gain additional insight into the basis for children's judgments. For example, if children consistently say that it's "not okay" to change either the control or the conventional patterns—which is, in fact, our prediction—one might argue that they do so for some superficial reason (e.g., they have a "no" bias), and not because they routinely make sense of observed patterns in inherent terms. However, if children systematically differentiate between the conventional and control patterns in their open-ended justifications, low-level interpretations of their responses become less plausible. (Because such interpretive concerns are not plausible with respect to adults' responses, their justifications are not reported here.)

3.1.1.4. Coding of the open-ended justifications. Because the modal response for children was that it was "not okay" to change the patterns, our coding focused on children's justifications for this subset of

[5] Because adults saw the four response options at the same time, the probability that they would choose "okay" by chance is .25. In contrast, because the children were first asked to make a dichotomous "okay" vs. "not okay" decision, the probability that they would choose "okay" by chance is .50. This feature of the design afforded a conservative test of our main prediction that adults would be more likely than children to say that change is "okay."

answers. A preliminary inspection of these justifications revealed two categories that seemed to account for most of the responses. The first category consisted of justifications that pointed out specific negative consequences that would follow from the proposed change (e.g., it's not okay to change the shape of coins "because if they were in a square then the edge would hurt the finger," "because the presidents wouldn't fit on them," or "because they won't really fit in your pockets"). The second category consisted of justifications that implied the change would go against the constitution of the relevant objects—against what they are supposed to be like (e.g., it's not okay to change the shape of coins "because they have to be round to be real money," "because they're supposed to be round," or "because they are always round"). A researcher went through the 48 transcripts and coded whether the justification for each "not okay" response fit into one of these two categories. To assess reliability, another researcher independently coded 38 of the transcripts. (The remaining 10 transcripts were used for training the second coder.) Agreement between the two coders was excellent: 95.1% and 98.0% (Cohen's kappas = 0.90 and 0.91) for the "negative consequence" and "supposed to be" explanations, respectively. Together, these two categories accounted for 77% of all justifications for why it is "not okay" to change the patterns we asked about.

3.1.2. Results and discussion

In the context of the present experiment, our account predicts a significant Pattern × Age interaction: Children should be more likely than adults to infer that conventional patterns such as that coins are round (which children seem to explain predominantly in inherent terms [see Experiments 1–3]) are inalterable. In contrast, children and adults should be in agreement that changes are "not okay" in the case of control patterns such as that pillows are soft.

An OLR on participants' alterability ratings identified a main effect of Pattern ($M_{conventional}$ = 2.05 vs. $M_{control}$ = 3.04 on a scale from 1 ["okay" to change] to 4 ["really not okay"]), Wald $\chi^2(1) = 73.48$, $p < .001$; a main effect of Age ($M_{children}$ = 2.78 vs. M_{adults} = 2.31), Wald $\chi^2(1) = 10.60$, $p = .001$; and the predicted Pattern × Age interaction, Wald $\chi^2(1) = 13.40$, $p < .001$.

To pinpoint the source of this interaction, we compared children's and adults' responses separately for the conventional and control patterns (see Table 6). Consistent with our argument, children were less likely to endorse changing the conventional patterns than the adults were (*M*s = 2.45 and 1.66, respectively), Mann–Whitney $p < .001$. (All follow-up comparisons between children and adults, here and in the next study, were performed using non-parametric Mann–Whitney *U* tests for unpaired data.) In contrast, and also consistent with our argument, children and adults did not differ in their responses for the control patterns (*M*s = 3.11 and 2.97, respectively), Mann–Whitney $p = .500$. Regardless of age, participants judged the control patterns to be inalterable.

The fact that children viewed a wide range of patterns as inalterable was predicted a priori by, and thus provides support for, our theoretical account regarding the developmental trajectory of the inherence heuristic. However, an alternative interpretation of this result might be that children's responses stemmed from a low-level bias to say "no." One piece of evidence against this interpretation is that, even though children were generally unlikely to endorse change, their responses did in fact differentiate between the two pattern types, with the control patterns being seen as even less changeable than the conventional ones, Wilcoxon $p < .001$. This result suggests that children understood the task and gave reasoned responses to the experimenter's questions.

To further explore this point, we also analyzed the justifications children gave for their "not okay" answers. Contrary to the response bias alternative, children tailored their justifications to the type of

Table 6
Average ratings in Experiment 4 by age group and pattern type (standard deviations in parentheses).

Age group	Conventional patterns	Control patterns
Children	2.45 (0.96)	3.11 (0.66)
Adults	1.66 (0.79)	2.97 (0.81)

Note. The ratings could range from 1 = "okay" to 4 = "really not okay" to make a change to the pattern in question (e.g., coins being round).

pattern they were asked about. For example, children brought up the potential negative consequences of the proposed change more often for the control than for the conventional patterns ($M_{conventional}$ = 50.6% vs. $M_{control}$ = 66.5% of "not okay" justifications), Wilcoxon p = .084. The disruptive effects of changing the patterns in our control set are quite obvious (e.g., hard pillows would hurt people's necks), and so it is reasonable for children to mention these potential disruptions most frequently when they justify why the control patterns cannot be changed. Because the negative consequences of changing *conventional* patterns are not immediately apparent, children sensibly invoked vaguer, yet still inherence-related, reasons to justify their intuition that these patterns cannot be changed—specifically, they appealed to what the relevant objects are "supposed to be" like, $M_{conventional}$ = 22.2% vs. $M_{control}$ = 10.1% of "not okay" justifications, Wilcoxon p = .034. After all, if a pattern (e.g., that coins are round) is explained via some inherent feature of its constituents (e.g., coins are money), it makes perfect sense to assume that the pattern *has* to be exactly as it is. These analyses reveal, again, that children understood our questions and provided responses that were in many ways quite sensible.

In sum, Experiment 4 provides converging evidence for our predictions. Although we used a different set of patterns than in Part I and a different dependent measure (namely, participants' intuitions about the inalterability of observed patterns), we nevertheless found precisely the same developmental differences as in the first three studies.

3.2. Experiment 5

In Experiment 5, we examined participants' intuitions about the *temporal stability* of observed patterns. We predicted that these intuitions would show the same developmental differences as were found in the first four studies.

3.2.1. Method

3.2.1.1. Participants. The participants were 48 children (M_{age} = 5.81 years, SD = 1.12; 24 girls and 24 boys) and 48 adults (29 women and 19 men). One additional child was tested but excluded from the sample because he did not complete the task.

3.2.1.2. Materials and procedure. The conventional and control patterns were the same as in Experiment 4 (see Table 5). The questions, however, concerned the temporal stability of these patterns. Specifically, we asked two questions: one about *past* stability (e.g., "Do you think coins have always been round, even way back when the first ever coin was made? Have coins always been round?"), and one about *future* stability (e.g., "Do you think coins will always be round, even way into the future, when the very last coin is made? Will coins always be round?"). The order of the past and future stability questions was fixed. "Yes" responses were assigned a numerical value of 1; "no" responses were assigned a 0. Participants' responses were averaged across the past and future stability questions (Cronbach's alpha = .68) to form a temporal stability index (range = 0–1), with higher values indicating stronger intuitions that observed patterns are temporally stable. (For completeness, Table 7 presents the means for the past and future questions separately, as well as for the composite stability index.)

Table 7
Average scores in Experiment 5 by question, age group, and pattern type (standard deviations in parentheses).

Question	Age group	Conventional patterns	Control patterns
Past stability	Children	0.61 (0.33)	0.79 (0.31)
	Adults	0.14 (0.21)	0.74 (0.22)
Future stability	Children	0.72 (0.31)	0.81 (0.28)
	Adults	0.31 (0.34)	0.89 (0.19)
Overall temporal stability	Children	0.67 (0.28)	0.80 (0.23)
	Adults	0.22 (0.25)	0.82 (0.17)

Note. The scores could range from 0 to 1, with higher scores indicating more stability. The past stability and future stability scores were calculated as the average proportion of "yes" responses to each of these questions. The overall temporal stability score was calculated as the average of the other two stability scores.

3.2.2. Results and discussion

As in the previous study, our main prediction was that of a Pattern × Age interaction stemming from (1) a developmental decrease in intuitions about the stability of the conventional patterns (e.g., that coins are round), combined with (2) relatively age-invariant intuitions about the highly stable nature of the control patterns (e.g., that pillows are soft).

An OLR on the temporal stability index uncovered a main effect of Pattern ($M_{conventional}$ = 0.45 vs. $M_{control}$ = 0.81), Wald $\chi^2(1) = 81.48$, $p < .001$; a main effect of Age ($M_{children}$ = 0.73 vs. M_{adults} = 0.52), Wald $\chi^2(1) = 21.80$, $p < .001$; and the predicted Pattern × Age interaction, Wald $\chi^2(1) = 34.38$, $p < .001$.

Unpacking this interaction (see Table 7 for means), we found that, as predicted, the children judged the conventional patterns to be more temporally stable than the adults did (*M*s = 0.67 and 0.22, respectively), Mann–Whitney $p < .001$. Also as predicted, both children and adults judged the control patterns to be highly temporally stable (*M*s = 0.80 and 0.82, respectively), Mann–Whitney $p = .858$.

Finally, we considered the possibility that the children said "yes" as often as they did because they were unable to understand the questions, or because they were confused by other aspects of the task. Contrary to this possibility, the children did in fact differentiate significantly between the conventional and control patterns, *M*s = 0.67 and 0.80, respectively, Wilcoxon $p < .001$. Such a difference would be unlikely if children did not understand what we asked of them. Thus, it seems more plausible that their responses stemmed directly from their intuitions about the (high) temporal stability of observed patterns.[6]

In sum, the results of Experiment 5 suggested that people's intuitions about the temporal stability of observed patterns follow the developmental trajectory predicted by the inherence heuristic account. Thus, Experiment 5 provided additional converging evidence in support of this account.

4. Age-related decreases in heuristic thinking within the child sample

In our analyses so far, we have treated the child participants as a unitary group. However, the child samples in our studies spanned a fairly wide age range, including children from 4 to 7 years of age. Thus, we might ask: Are there decreases in inherence-based intuitions across this range as well (similarly to when we compared children and adults as groups)? More specifically, one might expect to see a negative relationship between children's age and inherence-based reasoning for the conventional items (where we have argued that most of the developmental change should occur) but not for the control items.

To test these predictions with high statistical power, we combined the data across the five experiments. However, because the experiments used different measures, we first standardized the data within each study (separately for the conventional and the control items) before pooling them.[7] To account for the nested structure of the data (participants nested within study), we analyzed the responses with a hierarchical linear model (e.g., Raudenbush & Bryk, 2002) implemented using the *xtmixed* command in Stata 12 (StataCorp, 2011). The model also allowed the intercept and the slope of the independent variable (children's exact age in years) to vary freely across the five studies rather than constraining these parameters to be the same.

When applied to the data for the conventional items, our model revealed the predicted negative relationship between children's age and their inherence-based intuitions, $b = -0.14$, $z = 2.52$, $p = .012$. In contrast, there was no significant relationship between age and children's responses to the control items, $b = 0.03$, $z = 0.50$, $p = .620$; this relationship was also significantly different from the one found for the conventional items, $b = 0.17$, $z = 3.11$, $p = .002$.[8] Thus, even *within* the sample

[6] Note that low-level alternative accounts would also need to explain why children should have a "no" bias in Experiment 4 and a "yes" bias in Experiment 5. The dramatic nature of the shift in children's responses seems most compatible with our account.

[7] For Experiments 1–3, we first computed the difference between children's evaluations of the inherent and extrinsic explanations, separately for the conventional and control items. It was these difference scores that we then standardized.

[8] For a comparison of the two relationships, we included both the conventional and the control items in a single model. In this pooled model, the interaction between age and item type provides a test of whether age has a different relationship with responses to the conventional vs. the control items.

of children, inherence-based intuitions were more prevalent at younger ages, and specifically so for the conventional items, where we predicted they would be.

5. General discussion

People seem motivated to make sense of the world—to understand the larger systems they are part of. Accurate answers to such questions, however, cannot be found without considerable, sustained cognitive effort. Consider, for example, how many thousands of years it has taken humans to come up with (roughly) adequate means of explaining some of the most basic aspects of everyday experience, such as that objects fall when released or that living things get sick. And yet, people are seldom at a loss when casually wondering why things are the way they are. Quite the contrary—explanatory intuitions often spring to mind, without any prior knowledge of an answer. How do we arrive at seemingly effortless answers to questions that are so clearly not amenable to such answers? Cimpian and Salomon (2014-a, 2014-b; Cimpian, in press) termed the cognitive process that generates these quick-and-easy intuitions the *inherence heuristic*. In the present research, we explored the developmental predictions of this account. The first, most basic, prediction was that the hallmarks of this heuristic should be present in children's explanations. Moreover, since the cognitive resources that can help overcome heuristic reasoning are particularly scarce in childhood, our second prediction was that children would rely on inherence-based explanations in more instances than adults would.

5.1. Summary of results

In the three studies in Part I, we asked children and adult participants to evaluate inherent and extrinsic explanations for a number of broad patterns. To provide a stringent test of our predictions, we also varied a number of important stimulus dimensions across these studies: namely, the content of the inherent and extrinsic explanations, as well as of the patterns we asked about. Despite these variations in the stimuli, the three studies revealed essentially the same results: Consistent with our first prediction, children displayed a preference for inherent over extrinsic explanations, suggesting that inherence-based reasoning may indeed be prevalent early in development. Consistent with our second prediction, the preference for inherent explanations was broader for the children than for the adults.

The two studies in Part II provided convergent evidence for our predictions. In these studies, we investigated two intuitions that accompany inherence-based explanations: intuitions about inalterability, and intuitions about temporal stability. As we had hypothesized, participants' judgments along these two dimensions followed the same course as their explanations did in Part I: Children displayed a broad expectation that the patterns around them are inalterable and temporally stable. Adults, in contrast, were more likely to acknowledge the mutability and transience of the patterns they were asked about, and in particular of the patterns that have a conventional/extrinsic source. Taken together, these studies provide strong support for our argument concerning the developmental trajectory of the inherence heuristic.

To reiterate, however, the fact that adults were less likely than children to reason inherently about the conventional patterns in our studies does not mean that the inherence heuristic is absent beyond childhood. Rather, the effort-saving tendencies that lead people to explain heuristically are present throughout the lifespan (e.g., Gilovich, Griffin, & Kahneman, 2002; Kahneman, 2011; Shah & Oppenheimer, 2008). This claim is supported by the supplemental results described in Appendix B, which revealed that adult participants' responses in our studies were significantly predicted by several measures of heuristic thinking (see also Salomon & Cimpian, 2014). In sum, our argument here is simply that, by the time they reach adulthood, people may be better able to limit the influence of heuristic processes on their reasoning, at least to some extent (see also Kokis, Macpherson, Toplak, West, & Stanovich, 2002; Toplak, West, & Stanovich, 2014).

5.2. Alternative interpretations

In what follows, we discuss three potential alternative interpretations of the results presented here.

5.2.1. Psychological essentialism

According to a prominent hypothesis about the structure of concepts, people assume that there exist physical, internal entities that underlie membership in natural kinds and (some) social categories, and that also cause the members of these categories to have the properties they do (e.g., Bloom, 2004; Dar-Nimrod & Heine, 2011; Gelman, 2003; Medin & Ortony, 1989; Waxman, Medin, & Ross, 2007). Could our experiments be simply tapping people's assumptions about these "essences"?

Two aspects of the present studies speak against an essentialist interpretation. First, we asked participants about a much broader variety of patterns than what falls under the scope of essentialism (e.g., the color of school buses, the shape of coins); according to most accounts, essentialism applies only to natural and social categories (but see Bloom, 1996; Gelman, 2013). Second, we asked participants to evaluate explanations that fall outside the scope of canonical essentialist accounts. Essentialist beliefs are exclusively causal (e.g., Gelman, 2003), whereas the inherence heuristic is less selective and more opportunistic (since speed is crucial for any heuristic process). As a result, children's endorsement of value-laden explanations for observed patterns (such as that stars work best for police officers' badges; see Experiment 3) is more straightforwardly accounted for by an inherence heuristic rather than a belief in an internal, causally-powerful essence. Owing to these features of our design, the reliance on inherent explanations that we have uncovered in these studies cannot plausibly be explained by the hypothesis that people attribute causal essences to natural and social kinds.

5.2.2. Principled connections

According to a hypothesis developed by Prasada and his colleagues, the human conceptual system recognizes several types of connections between categories (or kinds) and their features (Prasada & Dillingham, 2006, 2009; Prasada et al., 2013). Most relevant here, some features have a *principled* connection with their kind. These features are understood to be present in instances of a kind simply by virtue of their membership in the kind (e.g., fire trucks have hoses simply because they are fire trucks). Principled connections thus license explanations in terms of kind membership ("*X*s have *Y* because they are *X*s"), which are termed *formal explanations*. From this perspective, the present findings might be interpreted as revealing a tendency to assume—as a default—that features have principled connections with their kinds. This tendency might lead people to overuse formal explanations even in cases where they are not appropriate (e.g., fire trucks are red because they are fire trucks). Similarly, it may lead to overly strong intuitions about the stability and inalterability of observed features (e.g., fire trucks will always be red).

However, there is little independent evidence to justify the idea that human cognition is biased to assume principled connections. Prasada and colleagues argue that principled connections are one of the three basic means we have of representing the relationship between categories and their features (the others are *statistical* and *causal* connections; see Prasada et al., 2013). Why would the conceptual system favor one of these fundamental modes over the others (such that children would start out assuming that features are bound to categories via principled, as opposed to statistical or causal, connections)? Such a bias cannot be motivated by appealing to difficulties in children's reasoning about statistical and causal relationships. In fact, the literature contains many examples of early competence both with respect to the ability to keep track of statistical regularities (e.g., Denison & Xu, 2014; Saffran, Aslin, & Newport, 1996) and with respect to causal learning (e.g., Leslie & Keeble, 1987; Schulz, 2012). But if computational difficulties cannot be used to motivate a bias toward principled connections, then it becomes unclear where else to turn in order to justify such a bias.

In contrast, the inherence heuristic proposal is firmly anchored in (1) the literature on reasoning, which suggests that human cognition employs a variety of implicit effort-reduction strategies (e.g., Shah & Oppenheimer, 2008), as well as in (2) research on the organization of memory, which suggests that inherent facts are highly accessible to reasoning processes (e.g., McRae et al., 2005). This theoretical foundation enabled us to derive an a priori prediction about the negative relationship between participants' age and the prevalence of inherence-based explanations, both on a broad temporal scale (comparing children and adults) and within a more restricted developmental window (comparing younger and older children). This foundation also allowed the inherence heuristic account to be fairly specific about the cognitive mechanisms that underlie people's reliance on inherent explanations (see

Section 1.1). In contrast, the principled connections alternative posits that participants behaved as they did in our tasks because they were biased to behave that way; this view provides little mechanistic insight into the phenomenon under investigation. For these reasons, we favor the inherence heuristic interpretation of the present results.

Nevertheless, the foregoing discussion does highlight a limitation of this research: Because the explanations and questions in our studies did not refer explicitly to inherent features, the support that these studies provide for the inherence heuristic proposal is somewhat indirect. To reiterate, our use of stimuli that were phrased in general terms was motivated by the fact that participants had to *evaluate* explanations; this paradigm only works if the explanations are general enough to capture most people's intuitions. Moreover, we provided empirical evidence linking the explanation stimuli with the inherence heuristic account (see Appendix A). Even so, future work with stimuli whose reliance on inherent facts or features is more obvious could further strengthen our claims.

5.2.3. Inherent explanations or no explanations?

A final alternative explanation we will consider here is that perhaps young children have *no* explanatory intuitions rather than inherence-based ones. If children seldom consider why things are the way they are, inherence-based explanations might be more appealing to them simply because these explanations generally stay closer to the actual phenomena—they invoke only information about the focal entities rather than bringing in outside explanatory factors. As a result, inherent explanations might be easier to think about and endorse for someone who has never before considered why the relevant patterns are in place. According to this interpretation, children's preference for inherent explanations is an artifact rather than a reflection of how children make sense of reality.

Several considerations speak against this alternative interpretation. First, this alternative stands in contrast to the extensive research documenting young children's eagerness to find out *why* things around them are as they are (e.g., Callanan & Oakes, 1992; Chouinard, 2007; Hickling & Wellman, 2001; Hood & Bloom, 1979), as well as their persistence in pursuit of an adequate explanation (e.g., Frazier, Gelman, & Wellman, 2009). Second, the idea that children have no explanations is difficult to reconcile with their strong intuitions about the inalterability and temporal stability of the patterns we asked about (Part II). In principle, having no clue why things are a certain way should lead to agnosticism about whether things could (or will) be different, but that is certainly not what we observed. Third, this alternative interpretation is contradicted by children's ability to make fine-grained discriminations among our stimuli. For example, children in Part I appropriately judged the inherent explanations to be more appropriate for the control patterns and, conversely, the extrinsic explanations to be more appropriate for the conventional patterns (see Section 2.4). Children similarly differentiated between the control and conventional patterns in Experiment 4 (inalterability) and Experiment 5 (temporal stability). It is hard to see how children could distinguish between these different types of patterns in the absence of any intuitions about their source.

5.3. Implications for children's understanding of moral vs. social-conventional norms

As it may already be apparent, the output of the inherence heuristic often informs people's judgments about what *should* be the case (see also Cimpian & Salomon, 2014-a). Thus, our account has implications for theories that seek to chart the development of children's reasoning about norms and morality. For example, the *domain theory* of moral development posits that children distinguish from a young age between a *moral* domain (which encompasses issues of fairness, harm, and personal rights) and a *social-conventional* domain (which encompasses contingent social rules and customs; for a recent review, see Helwig & Turiel, 2011). According to this theory, by the age of 4 or 5 children understand that social-conventional patterns are arbitrary, alterable by social consensus, and limited to particular contexts rather than being universal. Our results, however, throw some doubt on the conclusion that young children fully grasp which patterns are conventional and which are not. Relative to adults, the children in our studies showed much less understanding of the conventional origins of many patterns such as that coins are round, that fire trucks are red, or that police officers have stars on their badges. Thus, while children may be able to understand *some* patterns as mere social conventions (e.g., that teachers are called "Mr." and "Mrs."), it would appear that achieving this understanding for the full range of patterns and uniformities that are conventional in nature has a more protracted developmental course than allowed by domain theory.

In future work, it would be fruitful to investigate why children understand some patterns but not others as conventional early on. What enables young children to overcome their tendency to interpret patterns in inherent terms? One speculative possibility is that the rules of conduct typically investigated in research on domain theory (e.g., we don't stand during naptime) are particularly easy to understand as arbitrary conventions for a number of reasons: They apply in a restricted context (e.g., at school), and may actually vary across contexts (e.g., at home, it's okay to stand during naptime); they may be violated relatively often; children may have many opportunities to observe that violating these regularities does not have serious consequences; and so on. In contrast, many other conventional regularities that characterize our world (particularly ones that are broader, more stable, and more removed from children's usual sphere of activity) may not offer up as much evidence to contradict children's inherent notions. As a result, children's understanding of these other regularities may be shaped by the inherence heuristic for far longer than the behavioral/conduct rules investigated by domain theorists.

6. Conclusion

The inherence heuristic supplies easy answers to difficult *why* questions about the world. The ease with which these answers are generated comes at a cost, however: The heuristic overuses highly accessible information about inherent features. In the present studies, we explored the developmental trajectory of this explanatory heuristic. Our results suggested that children are particularly susceptible to its influence, and thus particularly likely to make sense of the world around them in inherent terms. These results, and the inherence heuristic proposal more generally, provide a promising new perspective on the development of children's concepts—a perspective that may also reveal the deep links between aspects of development that have so far been studied in relative isolation (e.g., categorization, heuristic vs. analytic thinking, moral judgment).

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Appendix A. Validation studies

A.1. Experiments 1 and 2

A.1.1. Pattern validation

To validate our assignment of the eight patterns/items (see top of Table 1) to the conventional set vs. the control set, we conducted a norming study with 70 participants recruited through Amazon's Mechanical Turk platform (41 women and 29 men). Participants read sentences describing the conventional and control patterns in each of the four matched pairs (e.g., "Fire trucks are red" and "Fire trucks have hoses") and were asked to select the one that was "more likely to be an arbitrary social convention." (The term *arbitrary social convention* was explained to participants at the beginning of the task.) Participants' responses validated our stimulus selection: They chose the items we had classified as conventional in 90.7% of cases, significantly more often than would be expected by chance (50%), $t(69) = 15.95$, $p < .001$. Each of the four matched pairs of conventional and control patterns conformed to this expected pattern (range of conventional patterns that were judged to be more conventional than their counterparts = 88.6–92.9%), binomial $ps < .001$.

A.1.2. Explanation validation

Because the explanations we termed *inherent* did not explicitly mention inherent features, we conducted a validation study ($N = 70$ Mechanical Turk participants; 36 women and 34 men) in order to verify the link between these explanations and our theoretical account. On each trial of this validation study, participants were first asked to imagine a person who believes than a certain pattern is due to the inherent features of its constituents (e.g., "that fire trucks are red because of some inherent feature of fire trucks and/or the color red"). Participants were then asked to predict whether this person would agree or disagree with the inherent and extrinsic explanations we used in the main study.[9] The order in which these two explanations were presented was randomized across participants, and responses were marked on a scale from 1 ("This person would strongly disagree") to 9 ("This person would strongly agree"). Participants' responses validated the mapping between our theoretical account and the explanations we used as stimuli: The inherent explanations used as stimuli were judged to follow from the premise that included explicit mention of inherent features ($M_{agreement} = 7.13$, which was significantly above the midpoint of the scale, $t[69] = 9.53$, $p < .001$). Also as expected, participants judged that the extrinsic explanations used as stimuli did *not* follow from the inherent premise ($M_{agreement} = 3.49$, which was significantly below the midpoint of the scale, $t[69] = 5.98$, $p < .001$).

A.2. Experiment 3

A.2.1. Pattern validation

A norming study with 70 Mechanical Turk participants (41 women and 29 men) validated our classification of the patterns used in Experiment 3 as conventional vs. control. Participants were asked to choose which of the two patterns in a matched pair (e.g., "School buses are yellow" [conventional] and "School buses have windows" [control]) was "more likely to be an arbitrary social convention." Participants' choices matched our classification on 90.0% of trials, significantly more often than would be expected by chance (50%), $t(69) = 19.42$, $p < .001$. Each of the four matched pairs of conventional and control patterns conformed to this expected pattern (range of conventional patterns that were judged to be more conventional than their counterparts = 87.1–92.9%), binomial *p*s < .001.

A.2.2. Children's familiarity with the patterns

A group of 32 children ($M_{age} = 5.92$ years, $SD = 1.01$; 16 girls and 16 boys) were tested to assess whether the patterns used in Experiment 3 are generally familiar to young children. On each trial, children were asked to decide which of two people was right: a person who claimed that a certain pattern was in place (e.g., "This person said that police officers have stars on their badges") or a person who claimed it was not (e.g., "This other person said that police officers do *not* have stars on their badges"). The order of the two options was counterbalanced across children, and the items also included several fillers for which the correct answer included a negation (e.g., "This person said that bananas are *not* purple") so as to avoid setting up the absence of a negation as a superficial cue to the correct answer. The results of this norming study confirmed that children of the age tested in our experiments are likely to be familiar with the set of patterns used in Experiment 3, $M = 86.7\%$ correct responses, $t(31) = 15.45$, $p < .001$, on a *t* test against chance (50%).

A.2.3. Explanation validation

To validate the link between the inherent explanations in Experiment 3 and our inherence heuristic proposal, we again sought to demonstrate that the more-general explanations used here follow directly from explanations that contain explicit mention of inherent features. A group of 70 Mechanical Turk participants (36 women and 34 men) were asked to predict whether a person who

[9] This belief prediction task presents an important advantage over an alternative task we considered but decided against. In this alternative task, participants would have been asked to assume that the premise concerning inherent features is true and then would have had to judge if the two explanations we used as stimuli follow from it. If participants happened to think that the premise is false in this alternative task, generating an appropriate response would have become challenging: Generally, people find it difficult to reason conditionally from false premises (e.g., Markovits & Vachon, 1989). Since reasoning about, and making predictions from, others' false *beliefs* presents comparatively little difficulty (e.g., Onishi & Baillargeon, 2005), the belief prediction task we chose is likely to be more straightforward for participants.

believes than a certain pattern is due to the inherent features of its constituents (e.g., that school buses are yellow "because of some inherent feature of school buses and/or the color yellow") would agree or disagree with the inherent and extrinsic explanations used in the main study. Participants' responses again demonstrated the unambiguous connection between our theoretical account and the explanations we used as stimuli: The inherent explanations were judged to follow from the premise that included explicit mention of inherent features ($M_{agreement} = 7.27$, which was significantly above the midpoint of the 1–9 response scale, $t[69] = 12.52$, $p < .001$). Also as expected, the extrinsic explanations used as stimuli did not follow from the inherent premise ($M_{agreement} = 4.27$, which was significantly below the midpoint of the 1–9 scale, $t[69] = 2.40$, $p = .019$).

A.3. Experiments 4 and 5

A.3.1. Pattern validation

To validate our classification of the eight patterns in Experiments 4 and 5 as conventional vs. control, we recruited 70 Mechanical Turk participants (41 women, 29 men) whom we asked to rate the extent to which each of the eight patterns (presented in random order) was an arbitrary social convention. Consistent with our classification, the conventional patterns (e.g., "Coins are round") were significantly more likely than the control patterns (e.g., "Wheels are round") to be judged as arbitrary social conventions, Ms = 6.66 and 3.04 (on a 1–9 scale), respectively, $t(69) = 10.68$, $p < .001$. The average ratings for all four conventional patterns were significantly above the midpoint of the 1–9 scale (range = 6.21–7.07), ts(69) > 4.80, ps < .001, whereas all four control patterns were significantly below the midpoint (range = 2.59–3.96), ts(69) > 3.36, ps $\leqslant$ .001.

Appendix B. Evidence for heuristic processing in our adult participants

We have argued that participants' intuitions across our studies stem from a heuristic process. To provide some evidence that this is indeed the case, we borrowed a strategy from the literature on heuristics and biases. Two signatures of heuristic responding that have been identified in this literature are that it is less common in (1) individuals who have ample cognitive resources, as well as (2) individuals who enjoy effortful thinking (e.g., De Neys, 2006; Epley & Gilovich, 2006; Stanovich & West, 1997, 2000; West, Toplak, & Stanovich, 2008). Thus, if the responses measured in our experiments are indeed the products of an inherence *heuristic*, they should also show these signatures.

To test this prediction, we collected some additional data from our 120 Mechanical Turk participants (24 per study). At the end of the experimental sessions, each of these participants was asked to complete three relevant measures: (1) an abbreviated version of Raven's Progressive Matrices, which is a common test of fluid intelligence (Raven, 1960); (2) the Need for Cognition scale, which measures participants' preference for complex, effortful thinking (e.g., "I find satisfaction in deliberating hard and for long hours"; Cacioppo, Petty, & Kao, 1984); and (3) a three-item scale devised in our lab to assess participants' preference for easy, intuitive explanations (e.g., "People who follow their gut instincts when trying to explain something usually get it right"; Salomon & Cimpian, 2014).

To derive a single index of the propensity to engage in heuristic vs. analytic reasoning, we submitted these three measures to a principal component analysis. Only one factor reached the minimum eigenvalue threshold (1.0) and was extracted from this analysis (eigenvalue = 1.34; 44.8% of variance accounted for). All three measures loaded highly on this "analytic reasoning" factor (loadings = 0.60, 0.71, and −0.69 for Raven's Progressive Matrices, Need for Cognition, and our measure of heuristic explanation, respectively). Participants' predicted scores on this factor served as the independent variable in our analyses. Participants' responses in the main tasks of our five studies (standardized within study) served as the dependent variable. These data were analyzed with a hierarchical linear model with study-specific random effects for the intercept and slope of subjects' analytic scores.

The results supported the claim that participants' responses were rooted in heuristic processing: Inherence-based responding to the conventional items was less common among the adults that had higher analytic reasoning scores, $b = -0.31$, $z = 3.59$, $p < .001$. However, no significant relationship was found for participants' responses to the control items, $b = 0.04$, $z = 0.49$, $p = .626$; moreover, this relationship was significantly different from that found for the conventional items, $b = 0.35$, $z = 3.19$,

$p = .001$. These results provide empirical evidence for the claim that our studies measure a type of *heuristic* thinking.

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