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Conceptual distinctions amongst generics

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ABSTRACT

Generic sentences (e.g., bare plural sentences such as "dogs have four legs" and "mosquitoes carry malaria") are used to talk about *kinds* of things. Three experiments investigated the conceptual foundations of generics as well as claims within the formal semantic approaches to generics concerning the roles of prevalence, cue validity and normalcy in licensing generics. Two classes of generic sentences that pose challenges to both the conceptually based and formal semantic approaches to generics were investigated. *Striking property generics* (e.g. "sharks bite swimmers") are true even though only a tiny minority of instances have the property and thus pose obvious problems for quantificational approaches, and they also do not seem to characterize kinds in terms of the principled or statistical connections investigated in previous research (Prasada & Dillingham, 2006, 2009). The second class — *minority characteristic generics* (e.g. "ducks lay eggs") — also poses serious problems for quantificational accounts, and appears to involve principled connections even though fewer than half of its instances have the relevant property. The experiments revealed three principal discoveries: first, striking generics involve neither principled nor statistical connections. Instead, they involve a causal connection between a kind and a property. Second, minority characteristic generics exhibit the characteristics of principled connections, which suggests that principled connections license the *expectation* that most instances will have the property, but do not require it. Finally, the experiments also provided evidence that prevalence and the acceptability of generics may be dissociated and provided data that are problematic for normalcy approaches to generics, and for the idea that cue validity licenses low prevalence generics. As such, the studies provided evidence in favor of a conceptually based approach to the semantics of generics (Leslie, 2007, 2008; see also Carlson, 2009).

1. Conceptual distinctions amongst generics

Much of our conceptual knowledge consists of generic knowledge – knowledge about kinds of things and their properties – and is expressed via generic sentences such as "tigers are striped", "ravens are black", and "cars have radios". The seemingly mundane nature of such sentences and the knowledge they express disguise the serious challenges generic sentences and generic knowledge pose. Despite significant efforts and some progress, linguists and philosophers have been unable to develop an adequate formal semantic analysis of generic sentences (Krifka et al., 1995; Leslie, 2008). Furthermore, though knowledge about kinds of things is at the core of our conceptual knowledge, research on concept acquisition and representation has generally proceeded without investigating the relationship between kinds and their characteristics that is revealed by our understanding of generic sentences. As a consequence, current theories of conceptual representation do not provide an account of how the knowledge expressed in generic sentences is represented (Prasada, 2012).

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Recently, however, the idea that generic sentences provide a window into our conceptual system has gained considerable traction (Carlson, 2009; Cimpian & Markman, 2009; Gelman, 2003, 2004; Gelman & Bloom, 2007; Hampton, 2009; Leslie, 2007, 2008, 2012; Pelletier, 2009; Prasada, 1999, 2000, 2010, 2012; Prasada & Dillingham, 2006, 2009). Specifically, generic sentences reveal the distinct ways in which our conceptual systems can represent connections between kinds and properties. On this view, which may be dubbed the *conceptually based* approach to generics, generic sentences give voice to our cognitive system's default modes of conceiving of kinds (Leslie, 2007, 2008, 2012), so that an adequate account of the meanings of generic sentences requires an understanding of the ways in which we represent connections between kinds and properties.

The conceptually based approach contrasts with the formal, quantificational approaches to generics that have dominated the semantics literature. These formal approaches seek to analyze generics using the set-theoretic tools of formal semantics, and usually involve positing some kind of covert quantification – for example, generics may be analyzed as containing an implicit quantifier (e.g. "all"), which is often taken to range over the normal instances of the kind. Thus "tigers are striped" would be analyzed as meaning something like "all normal tigers have stripes" (see Carlson & Pelletier, 1995, for examples of such accounts, especially in the introductory chapter). Such accounts aim to reduce generics to set-theoretic, quantificational claims. The conceptually based approach, in contrast, aims to understand generics in the context of the various ways in which we represent connections between kinds and properties.

The primary goal of the experiments in the present paper is to investigate the types of connections our conceptual systems represent between kinds and properties. In so doing, they reveal domain-general ways in which our concepts of kinds are structured (Prasada & Dillingham, 2009). In addition, they provide a characterization of the cognitively fundamental modes of generalization that are hypothesized to underlie generic sentences (Leslie, 2007, 2008, 2012; see also Carlson, 2009). The experiments also address a number of claims that have been made concerning the semantics of generics within the linguistics literature.

1.1. Representing generic knowledge via principled and statistical connections

Our conceptual systems distinguish at least two types of connections, principled and statistical, between kinds and their properties, and thus provide at least two ways to characterize kinds and represent generic knowledge (Prasada & Dillingham, 2006, 2009). Principled connections involve properties that instances of a kind have by virtue of their being the kinds of things they are (e.g., having four legs for a dog) and they involve three dimensions: an explanatory dimension, a normative dimension, and a statistical dimension. Principled connections support *formal explanations* whereby a property of an instance of a kind is accounted for by reference to the kind of thing it is (e.g., "Fido has four legs *because* he is a dog"). They also license *normative expectations*: we expect that instances of the kind *should* have the properties to which the kind has a principled connection (e.g. "Fido, by virtue of being a dog, *should* have four legs"). Instances that lack the property are judged to be defective or incomplete rather than merely atypical. Finally, principled connections ground the expectation that the property will generally be *highly prevalent* (e.g., "*most* dogs are expected to have four legs"). Properties that have a principled connection to a kind are represented as *aspects of being that kind of thing* (Prasada & Dillingham, 2009). Generic knowledge that involves principled connections may be expressed in generic sentences that either have the bare plural form (e.g., "dogs have four legs") or the indefinite singular form (e.g., "a dog has four legs") in English (Leslie Khemlani, Prasada, & Glucksberg, 2009; Prasada & Dillingham, 2009).

Statistical connections, on the other hand, involve properties that are simply prevalent amongst instances of a kind (e.g., being red for a barn). Statistical connections do not support formal explanations or normative expectations. Furthermore, properties that have a mere statistical connection to a kind are not represented as aspects of the relevant kind of thing. Generic knowledge involving statistical connections may be expressed via generic sentences that have the bare plural form (e.g., "barns are red"), but not the indefinite singular form (e.g., #"*a barn is red*") in English (Leslie et al., 2009; Prasada & Dillingham, 2009). Thus, principled and statistical connections provide two different means for characterizing kinds, and reflect at least two different ways in which our generic knowledge can be represented.

Both principled and statistical connections provide a means for characterizing kinds generally and are available for characterizing kinds irrespective of content domains. In particular, Prasada and Dillingham (2006, 2009) found that the distinction between principled and statistical connections applies to natural, artificial and social kinds. Furthermore, there is an asymmetry between the two connections: when there is a principled connection between a kind and a property, there is also a statistical connection between the two. However, the presence of even a strong statistical connection does not in itself implicate a principled connection between the kind and the property (Prasada & Dillingham, 2006).

1.2. Are principled and statistical connections sufficient for characterizing our generic knowledge?

A natural question is whether principled and statistical connections are sufficient for characterizing all of our generic knowledge. There are two classes of generic knowledge that seem to involve connections that are neither principled nor statistical, at least as currently conceived. The first class consists of generalizations such as "pit-bulls maul children" or "sharks attack swimmers".[1] In these cases, it appears that the property can hold for just a very small percentage of the instances of the kind and yet the

[1] Whether and how such generics constitute a class of knowledge or of sentences is a theory-dependent question. In calling them "classes", we are pointing to sets of generics that share some salient properties and that may plausibly constitute a class, but what is important here is that they do not obviously involve principled or statistical connections.

generic will be licensed (Cimpian, Brandone, & Gelman, 2010; Leslie, 2007, 2008, in press). Such low-prevalence generics tend to involve striking (good or bad) properties and thus have been dubbed *striking property generics* (Leslie, 2007, 2008, in press). The existence of striking property generics shows that high prevalence is not necessary for generic beliefs. Not only does it seem that striking property generics can be true even when a small percentage of instances have the property in question, but they also do not seem to involve an expectation that most instances would or should have the property. As such, striking property generics seem to involve a type of connection that is neither principled nor statistical.

Leslie (2007, 2008, in press) and Prasada (2010) suggest that striking property generics involve *causal connections* between the kind and the property, in the sense that the shared nature of the members of the kind causes them to be disposed to have the property in question, whether or not they actually do. For example, even though most ticks do not carry Lyme disease, their common biological makeup causes them to be susceptible to carrying the disease. According to Leslie and Prasada, such a causal connection between the kind and the property is required for a striking property generic to be accepted. Furthermore, though principled connections and causal connections often co-occur, they can also be decoupled (Prasada & Dillingham, 2006, 2009). For example, though there is a principled connection between being a triangle and being three-sided, there is no causal connection, since triangles are abstract entities. Conversely, though there is likely a causal connection between being a deer tick and carrying Lyme disease, there is no principled connection between the two because carrying Lyme disease is unlikely to be thought of as an aspect of being a deer tick (see Experiment 1 below). While the conceptually based approach can readily accommodate striking property generics, they have proved intractable for the standard formal semantic approaches. Previous discussions of striking property generics have almost exclusively relied on theorists' intuitions rather than on data from naïve participants (but cf. Cimpian et al., 2010). Since striking property generics provide an important piece of evidence in adjudicating between different theories of generics, Experiment 1 sought to confirm that people do indeed accept them despite knowing that very few members of the kind have the property. Experiment 3 investigated whether striking property generics involve a causal connection between the kind and the property.

A second class of generics that does not straightforwardly involve principled or statistical connections is what Leslie (2007, 2008) calls *minority characteristic generics* such as "ducks lay eggs" and "lions have manes." Minority characteristic generics are similar to generics that involve principled connections in that they involve properties that seem to be part of the nature of the kind. However, they differ from principled generics in that they involve properties that are possessed by less than half of the instances of the kind (e.g., only fertile, mature female ducks lay eggs). As such, they may differ from both principled and statistical generics and potentially constitute a fourth type of generic. Alternatively, minority characteristic generics may involve principled connections, since principled connections ground only the *expectation* that most or all instances of the kind will have the property, but do not *require* this to be the case. Prasada and Dillingham's (2006, 2009) stimuli only included items for which most or all instances had the critical property. Thus, studies have not investigated whether principled connections are implicated when only a minority of the instances have the property.

Experiments 1 and 2 investigated whether minority characteristic generics display the non-statistical characteristics of principled connections. The experiments also investigated whether the connections that underlie striking generics differ from principled connections with respect to their explanatory and normative dimensions.

1.3. Formal semantic approaches to generics

While the primary goal of our studies was to examine the different ways in which we represent generic knowledge, we also addressed a number of claims in the formal semantics literature (e.g., Carlson, 1977; Carlson & Pelletier, 1995; Cohen, 1996; Lawler, 1973; Leslie, 2007, 2008; Pelletier & Asher, 1997). One claim is that some generics are deemed true even though very few members of the kind in question have the property (e.g., Leslie's (2007, 2008 in press) notion of striking property generics), and a complementary claim is that some generics are false even though the property is possessed by most members of the kind (e.g., Cohen, 1996; Leslie, 2007, 2008). Examples of the latter sort, which we called *majority false generalizations*, include statements such as "books are paperbacks" and "Canadians are right-handed." Since much weight has been placed on these claims, it is important to confirm that people's judgments are accurately represented. Further, the semantics literature tends to focus on a very limited number of examples – often just one or two examples of generics are provided to make a point. It is thus an open question whether these claims hold reliably over a larger range of example sentences. We expected that the consensus in semantics would be supported and the judgments would generalize to a larger set of items.

It is sometimes suggested that low prevalence generics such as "ticks carry Lyme disease" are only accepted because of the high associated *cue validity* – i.e., because of the high conditional probability of something being a tick given that it carries Lyme disease. If this is correct, then one would expect that the low prevalence striking property generics would only be accepted if they had high associated cue validities, and further, that the higher the cue validity, the more acceptable the generic would be. Experiment 1 investigates this possibility.

Another highly influential family of formal semantic accounts – which we refer to as the *normalcy approach* – relies on the idea that generics express claims about what is *normal* for the members of the kind, or, relatedly, about which properties they are *supposed* to have (e.g., Asher & Morreau, 1995; Carlson & Pelletier, 1995; Dahl, 1975; Krifka et al., 1995; Nickel, 2008; Pelletier & Asher, 1997). These formal semantic accounts do not simply claim that *some* generics (e.g., the ones that involve principled connections) communicate information about normalcy; rather, they aim to provide a uniform analysis of the conditions under which *any* generic statement will be true or false. To test the claims made by these normalcy accounts, we asked people to evaluate whether (a) *all normal* members of the kind have the property, and (b) whether members of the kind are *supposed* to have the property in question. Support for the normalcy approach would be found if people only accepted generics when they also accepted these other related claims. We predicted, however, that striking generics and statistical generics would be accepted, despite having low scores on these measures.

In what follows, we describe three experiments that sought to clarify the conceptual foundations of striking and minority characteristic generics and test some diverging claims between the conceptually based approach and the formal semantics approach to generic statements.

2. Experiment 1: Which types of generics involve principled connections?

The main goal of Experiment 1 was to investigate which types of generic knowledge involve representing a principled connection between a kind and a property. Of primary interest is whether striking property generics and minority characteristic generics involve principled connections. In addition to including striking property and minority characteristic generics, Experiment 1 included *majority characteristic* generics (e.g., "dogs are four legged") which clearly involve principled connections, as well as *majority statistical* generics (e.g., "barns are red") which clearly involve statistical connections. These items provided points of comparison for the striking property and minority characteristic generics. Cue-validities and prevalence estimates were also collected to test claims concerning the role of these factors in licensing generics. The various types of generic generalizations that we considered are provided in Table 1.

Experiment 1 investigated whether principled connections underlie generics for four *predication* types (e.g., majority characteristic, minority characteristic, majority statistical, and striking property; see Table 1) via truth-value judgments for five *assertion* types (see Table 2).

Four of the assertion types reflected principled connections ("in virtue of", "is an aspect of", "are supposed to", and "all normal", see Table 2), while the fifth assertion type (bare plural generic) is not a measure of whether a connection is principled or not. Participants judged the truth of each combination of assertion and predication. The conceptually based approach makes the following predictions.

2.1. Predictions of the conceptually based approach

(1) Majority characteristic predictations (e.g., "tigers have stripes") should be highly rated in all five assertion types, since they involve principled connections and support generic statements.
(2) Majority statistical predications (e.g., "cars have radios") should receive low ratings in all four assertion types that measure principled connections because they do not involve principled connections. However, they should nonetheless receive high ratings in the bare plural form.
(3) Minority characteristic predications (e.g., "lions have manes") should be rated much more highly than majority statistical predictations (e.g. "cars have radios") on the principled connection measures, with the exception of "all normal" assertions.
(4) Striking property predications (e.g., "pitbulls maul children"), like majority statistical predications (e.g., "cars have radios"), should receive low ratings in all assertion types except for the bare plural form.
(5) *Generics and prevalence*: striking property predications should be accepted in bare plural form despite having low prevalence estimates, whereas majority false generalizations (e.g. "books are paperbacks") should be rejected in bare plural form despite having high prevalence estimates.
(6) *Normalcy and generics:* "all normal" assertions should be rated highly only for the majority characteristic predications, and they should receive much lower ratings for all the other types of predications. We also predict "are supposed to" assertions, (e.g., pitbulls are supposed to maul children) should be rejected for striking property and majority statistical predications
(7) *Cue validity and striking property generics:* acceptability ratings of (low prevalence) striking property generics should not be affected by cue validity.

2.2. Method

2.2.1. Participants

One hundred and thirty seven volunteers participated in the experiment over the Internet. Participants were chosen from Amazon's Mechanical Turk system for human intelligence tasks (for an evaluation of the validity of this platform for psychological experimentation, see Paolacci, Chandler, & Ipeirotis, 2010). All spoke English as their first language and none had participated in experiments concerning generics before.

2.2.2. Materials and design

Twelve items of each of the four types of predications discussed above (i.e., majority characteristic, minority characteristic, majority statistical, and striking predications) were included in the experiment. The items were drawn from a larger set of items for which we collected cue validity and prevalence norms (see Appendix A). The criteria for determining predication type are summarized in Table 1. Half of the items for each type of predication involved a natural kind and the other half involved an artifact kind, except for the minority characteristic predications, which involved only natural kinds.[2] The four types of predications were matched with respect to the mean cue-validity of the properties they mentioned. In the norming study, participants estimated a mean prevalence of 58.99% for the minority characteristic items. Given this surprisingly high estimate, we sought to determine if the estimate was

[2] Only natural kind items were included as these are the types of examples which have been used in the literature on generics and we wanted to include only those items which clearly appear to involve principled connections despite being true of only a minority of instances.

Table 1
Types of predication used to generate assertions for Experiment 1.

Predication type	Example	Truth value of the generic	Description
Majority characteristic	Tigers are striped	True	Property must be prevalent though not universally had among members of the kind; some exceptional members (e.g., albino tigers) fail to possess it. Relevant ''by virtue'' paraphrase must sound acceptable (Prasada & Dillingham, 2006)
Minority characteristic	Lions have manes	True	Property must only be held by a minority of the kind, and must be central, principled or essential (Medin & Ortony, 1989; Gelman, 2003). For our purposes we restricted these items to methods of gestation, methods of nourishing the very young, and characteristic physical traits had only by one gender
Majority statistical	Cars have radios	True	Property must be prevalent among members of the kind, and must not be a majority characteristic connection (i.e. the ''by virtue'' paraphrase must sound unacceptable)
Striking	Pit bulls maul children	True	Property must only be had by a small minority of the kind, and must signify something dangerous and to be avoided
Quasi-definition	Ants are insects	True	Property must be universally true of all the members of the kind; no exceptions
Majority false generalization	Canadians are right-handed	False	Property must be prevalent among members of the kind and there must be a sufficiently salient alternative property (e.g. being a left-handed), so that the generic form of the predication sounds false or mistaken
Minority false generalization	Rooms are round	False	Property must be held by very few members of the kind but must not signify something dangerous. The generic form of the predication must sound false or mistaken

Table 2
Examples of the seven types of predication and five types of assertions used in Experiment 1.

Predication type	Aspect	By virtue	Normativity	All normal	Bare plural
Majority characteristic	Being striped is one aspect of being a tiger	Tigers, by virtue of being tigers, are striped	Tigers are supposed to be striped	All normal tigers are striped	Tigers are striped
Minority characteristic	Having a mane is one aspect of being a lion	Lions, by virtue of being lions, have manes	Lions are supposed to have a mane	All normal lions have manes	Lions have manes
Majority statistical	Having a radio is one aspect of being a car	Cars, by virtue of being cars, have radios	Cars are supposed to have a radio	All normal cars have radios	Cars have radios
Striking	Mauling children is one aspect of being a pit bull	Pit bulls, by virtue of being pit bulls, maul children	Pit bulls are supposed to maul children	All normal pit bulls maul children	Pit bulls maul children
Quasi-definition	Being an insect is one aspect of being an ant	Ants, by virtue of being ants, are insects	Ants are supposed to be insects	All normal ants are insects	Ants are insects
Majority false generalization	Being right-handed is one aspect of being a Canadian	Canadians, by virtue of being Canadians, are right-handed	Canadian are supposed to be right-handed	All normal Canadians are right-handed	Canadians are right-handed
Minority false generalization	Being round is one aspect of being a room	Rooms, by virtue of being rooms, are round	Rooms are supposed to be round	All normal rooms are round	Rooms are round

due to a bimodal response pattern in which most participants estimated the prevalence to be less than 50%, but a small number of participants estimated that most instances had the property, possibly due to their interpreting the task in a different manner. The distribution of responses was indeed bimodal (Hartigan's dip test = .059, $p < .0001$) with a large mode in the 40–50% range and a smaller mode in the 90–100% range. We will continue to use the term *minority characteristic* to refer to these predications for the sake of consistency. Though we will not be able to determine if principled connections can have estimated prevalences of less than 50%, the more important question is *whether* minority characteristic generics (e.g., ''ducks lay eggs'') involve principled connections or not. For this purpose, the items are ideally suited as their prevalences are significantly lower than those of the majority statistical items and thus provide a clear way to distinguish between the effects of principled connections and prevalence.[3]

We also included three other types of predications (majority false generalizations, minority false generalizations, and quasi-definitions) to encourage full use of the rating scale. The majority false generalizations (e.g., ''Canadians are right-handed'') were also of interest because they provide an opportunity to confirm that bare plural generics can be rejected despite high prevalence estimates. Minority false generalizations were statements

[3] An important question for future research is to determine exactly why participants had a tendency to overestimate the prevalence of the minority characteristic items. One intriguing possibility is that the over-estimations are a consequence of the knowledge being represented via principled connections.

Table 3
Mean truth-value ratings for predication types as a function of assertion type in Experiment 1.

Predication type	Aspect	By virtue	Normativity	All normal	Bare plural
Majority characteristic	2.40	2.25	2.40	2.09	2.48
Minority characteristic	1.48	1.28	1.40	.34	1.83
Majority statistical	.56	.02	.19	−.10	1.23
Striking	.75	.28	−.25	−1.27	1.27
Filler items					
Quasi-definition	2.44	2.71	2.57	2.13	2.62
Majority false generalization	−.26	−1.14	−1.17	−1.67	−.06
Minority false generalization	−.50	−1.77	−1.78	−2.45	−.76

that are deemed false as generics, such as "cats are white," in which the property is true of a minority of instances. Quasi-definitions were statements such as "ants are insects" in which the property was virtually definitional and often referred to a superordinate category. The full list of items is given in Appendix A.

For each predication, five assertions were generated. Four of the assertions specified phenomena reflecting principled connections (see Table 2). A bare plural form expressing generic knowledge was also generated. The materials generated a 7 (predication type) $\times$ 5 (assertion type) mixed factor design, with assertion type a between-participants factor and predication type a within-participants factor. Each participant received all 12 items of each type of the seven types of predications in one of five assertion types, i.e., 84 items in total. We chose to make assertion type a between-participants variable to allow comparisons of how each type of predication was rated for a given assertion type without interference from factors that may be relevant to judging other assertion types.[4] Each participant rated all the predications in one of the five assertion types.

2.2.3. Procedure

The experiment was run on the Internet using an experiment interface written in Ajax (Javascript, HTML, and PHP). For each assertion, participants were asked to evaluate the extent to which the assertion struck them as being true on a 7-point Likert scale, whose end points were labeled "definitely true" (+3) and "definitely false" (−3). After familiarization with the response scale, each participant received the items for a given assertion type in a different random order.

2.3. Results

Given the bi-modal prevalence estimates for the minority characteristic items, a Hartigan's dip test for bi-modality was performed on the data from the trials with the minority characteristic predications to determine if they received bi-modal responses in the present experiment as well which would suggest that participants interpreted these items in more than one way. The test revealed no tendency for bi-modality ($p > .5$) so the data can be interpreted straighforwardly.

The means for each predication type as a function of assertion type are presented in Table 3. A 4 $\times$ 5 omnibus ANOVA with the four non-filler classes of predications and the five assertion types revealed significant effects of predication type, assertion type, and a significant interaction between the two (see Table 4, Test 1).[5]

2.3.1. Do majority characteristic predications, unlike majority statistical predications, involve principled connections?

We predicted a large difference between majority characteristic predications (e.g., "tigers have stripes") and majority statistical predications (e.g., "cars have radios") on the four assertions that reflect principled connections, but a smaller or no difference between the two predications for the truth-value ratings of the bare plural generics.

A 2 $\times$ 5 ANOVA yielded the predicted interaction as well as significant main effects of predication type and assertion type (see Fig. 1; Table 4, Test 2). Planned t-tests with Bonferroni corrections for multiple comparisons revealed that majority characteristic predications receiving significantly higher ratings for all five assertion types, but, as predicted, the difference was smallest for the bare plurals. The details of these pairwise tests are reported in Appendix B (Test 1).

These data confirm that items that involve principled connections (majority characteristic predications) receive high scores on our principled connections measures, but items which clearly do not involve principled connections (majority statistical predications) receive lower scores on these measures.

2.3.2. Are minority characteristic predications represented via principled connections?

Based on the hypothesis that minority characteristic predications (e.g., "lions have manes") involve principled connections, we predicted a substantial difference between minority characteristic predications and majority statistical predications (e.g., "cars have radios") on three of the four principled connection measures, and smaller differences in judgments concerning whether all normal

[4] We ran a fully within-participants replication and found similar results. However we found some evidence that judgments for a given assertion type showed interference effects from judgments of other assertion types.

[5] The low ratings that minority characteristic items received when judging the *All normal xs are p* assertions rule out the possibility that participants were interpreting the assertions involving minority characteristic items as quantifying over kinds of kinds (e.g. interpreting *All normal ducks lay eggs* as *All normal kinds of ducks lay eggs*) or limiting their interpretation of the noun to the relevant subset of the kind (e.g. interpreting *lion* in *All normal lions have manes* to male lions). Had participants used either of these interpretive strategies, they would have rated the items highly on the "all normal" measure; however, this is not what we found.

Table 4
Summary of the ANOVA results for Experiment 1 ($N = 137$).

	Participant analysis		Item analysis		Combined	
ANOVA Test	F_1	p	F_2	P	min F'	p
1. *Omnibus*						
Predication type	$F(3,396) = 217.45$	<.0001	$F(3,44) = 61.91$	<.0001	min $F'(3,72) = 48.19$	<.0001
Assertion type	$F(4,132) = 13.00$	<.0001	$F(4,176) = 105.44$	<.0001	min $F'(4,165) = 11.57$	<.0001
Interaction	$F(12,396) = 6.85$	<.0001	$F(12,176) = 14.16$	<.0001	min $F'(12,571) = 4.62$	<.0001
2. *Majority characteristic vs. majority statistical*						
Predication type	$F(1,132) = 358.56$	<.0001	$F(1,22) = 135.12$	<.0001	min $F'(1,41) = 98.14$	<.0001
Assertion type	$F(4,132) = 5.25$	<.0006	$F(4,88) = 23.91$	<.0001	min $F'(4,183) = 4.31$	<.002
Interaction	$F(4,132) = 3.43$	<.01	$F(4,88) = 9.51$	<.0001	min $F'(4,205) = 2.52$	<.042
3. *Minority characteristic vs. majority statistical*						
Predication type	$F(1,132) = 82.84$	<.0001	$F(1,22) = 17.35$	<.0006	min $F'(1,32) = 14.34$	<.0006
Assertion type	$F(4,132) = 8.45$	<.0001	$F(4,88) = 42.22$	<.0001	min $F'(4,179) = 7.04$	<.0001
Interaction	$F(4,132) = 2.86$	<.026	$F(4,88) = 5.26$	<.0007	min $F'(4,218) = 1.85$	>.120
4. *Majority characteristic vs. minority characteristic*						
Predication type	$F(1,132) = 190.48$	<.0001	$F(1,22) = 29.69$	<.0001	min $F'(1,29) = 25.69$	<.0001
Assertion type	$F(4,132) = 6.27$	<.0001	$F(4,88) = 35.69$	<.0001	min $F'(4,174) = 5.34$	<.0004
Interaction	$F(4,132) = 5.79$	<.0001	$F(4,88) = 12.11$	<.0001	min $F'(4,215) = 3.92$	<.004
5. *Striking vs. majority characteristic*						
Predication type	$F(1,132) = 436.72$	<.0001	$F(1,22) = 262.20$	<.0001	min $F'(1,53) = 163.84$	<.0001
Assertion type	$F(4,132) = 15.39$	<.0001	$F(4,88) = 70.48$	<.0001	min $F'(4,183) = 12.63$	<.0001
Interaction	$F(4,132) = 13.66$	<.0001	$F(4,88) = 41.38$	<.0001	min $F'(4,201) = 10.27$	<.0001
6. *Striking vs. majority statistical*						
Predication type	$F(1,132) = 7.86$	<.006	$F(1,22) = 2.07$	>.164	min $F'(1,35) = 1.64$	>.208
Assertion type	$F(4,132) = 12.99$	<.0001	$F(4,88) = 74.25$	<.0001	min $F'(4,222) = 14.0$	<.0001
Interaction	$F(4,132) = 10.80$	<.0001	$F(4,88) = 12.30$	<.0001	min $F'(4,214) = 1.70$	<.0002

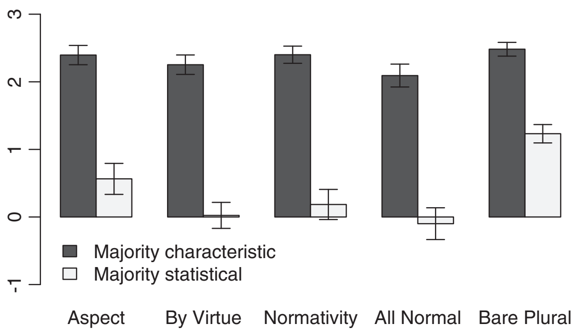

Fig. 1. Mean truth-value ratings (−3 to +3) as a function of assertion type for majority characteristic and majority statistical items in Experiment 1.

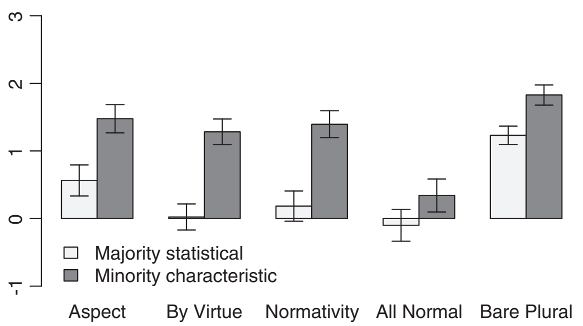

Fig. 2. Mean truth-value ratings (−3 to +3) as a function assertion of type for majority statistical and minority characteristic items in Experiment 1.

instances of the kind have the property and the ratings of the bare plural generics. This prediction was confirmed. A 2×5 ANOVA of predication type vs. assertion type with minority characteristic predications and majority statistical predications yielded the predicted interaction as well as significant main effects of predication type and assertion type (see Fig. 2; Table 4, Test 3). Pairwise *t*-tests with Bonferroni correction (Appendix B, Test 2) revealed that, as predicted, the minority characteristic predications received significantly higher ratings than the majority statistical predications on all the principled connection measures except the "all normal" measure. The minority characteristic predications also received a significantly higher rating on the bare plural assertion. Note that the minority characteristic items received higher ratings than the majority statistical items on all the principled connection measures except the "all normal" measure, despite the fact that the minority characteristic items had a significantly *lower* prevalence for the critical properties (58.99%) than the majority statistical items (67.97%; $t(11) = 2.38$, $p < .05$, $d = 1.28$; see Appendix A). This provides clear evidence that the distinction between principled and statistical connections cannot be reduced to a difference in prevalence. Furthermore, it rules out the possibility that minority characteristic predications reflect only statistical connections.

Because the minority characteristic items all involved natural kinds, it is important to see if the differences on the principled connections measures remain when only the natural kind majority statistical items are considered.

This analysis found that the minority characteristic items received significantly higher scores on all the principled connections measures.

2.3.3. Comparing minority characteristic and majority characteristic predications

We expected an interaction between predication type and assertion type for minority characteristic (e.g., "lions have manes") and majority characteristic predications (e.g., "tigers have stripes"). There should be small or no differences for all measures except the one concerning whether all normal instances of the kind have the property. A 2 × 5 ANOVA of predication type vs. assertion type with minority characteristic generics yielded the predicted interaction as well as significant main effects of predication type and assertion type (Table 4, Test 4). Pairwise *t*-tests with Bonferroni correction revealed that the majority characteristic predications were given higher ratings than the minority characteristic predications on all measures (Appendix B, Test 3), with the largest difference on the "all normal" assertion. The differences in ratings between majority and minority characteristic predications on measures other than the "all normal" measure are likely due to differences in the prevalence of the properties, which were significantly higher for the majority characteristic items (90.19%) than the minority characteristic items (58.99%, $t(11) = 16.87$, $p < .0001$, $d = 8.06$). This would be consistent with Prasada and Dillingham's (2006, 2009) finding that while principled and statistical connections cannot be distinguished on the basis of prevalence, prevalence nonetheless has a small but significant effect on participants' judgments (see also Khemlani, Leslie, & Glucksberg, 2012).

2.3.4. Are striking property generics represented via principled connections?

Striking property predications (e.g., "pitbulls maul children") should not involve principled connections and so we expected a large difference between striking property predications and majority characteristic predications (e.g., "tigers have stripes"), but a smaller or no difference in the ratings of the bare plural generics. These expectations were confirmed.

A 2 × 5 ANOVA found the predicted interaction as well as significant main effects of predication type and assertion type (Fig. 3; Table 4, Test 5). Pairwise *t*-tests with Bonferroni corrections for multiple comparisons revealed that the majority characteristic items received higher ratings for all five assertion types (Appendix B, Test 3), but, as predicted, the difference was smallest for the bare plurals. These data suggest that striking property generics are not represented via principled connections between a kind and a property. This conclusion is bolstered by the results of the next comparison.

2.3.5. Comparing striking property and majority statistical items

Since neither striking property (e.g., "pitbulls maul children") nor majority statistical predications (e.g., "cars have radios") are hypothesized to involve principled connections, we expected no main effect of predication type or interaction between predication type and assertion type.

A 2 × 5 ANOVA with striking and majority statistical items revealed no significant effect of predication type in the item analysis, but surprisingly, there was a significant effect in the participants analysis (see Fig. 4; Table 4, Test 6). There was also a significant effect of assertion type, and a significant interaction. Planned *t*-tests with Bonferroni corrections for multiple comparisons (reported in Test 5 of Appendix B) revealed that the striking property and majority statistical predications did not differ on any of the assertions except the one pertaining to whether all normal instances of the kind have the property in question. Participants denied this to be the case to a greater extent for the striking property predications than the majority statistical predications. Thus, as predicted, striking property predications mostly patterned like majority statistical predications on phenomena that reveal principled connections. The one assertion type for which the two types of predications differed was the extent to which they supported the expectation that all normal instances should have the property, with striking predications receiving a lower rating. This indicates that they are *less* like predications that involve principled connections on this measure than the majority statistical predications. These data strongly suggest that striking property predications are

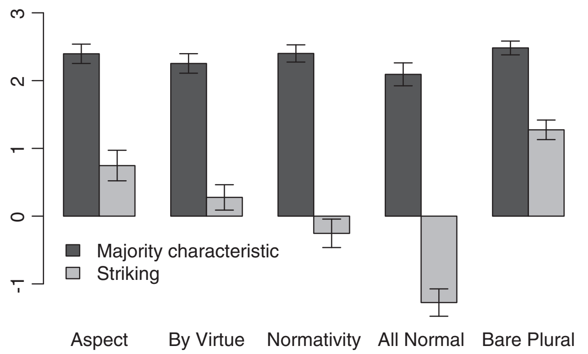

Fig. 3. Mean truth-value ratings (−3 to +3) as a function of assertion type for majority characteristic and striking items in Experiment 1.

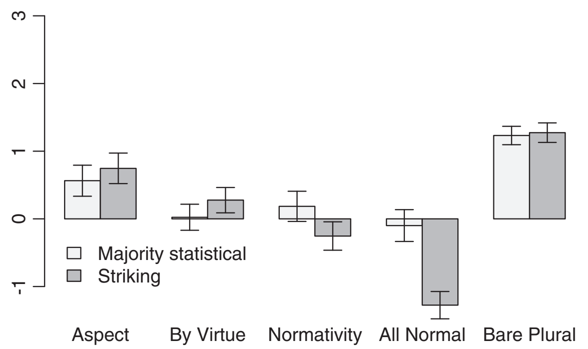

Fig. 4. Mean truth-value ratings (−3 to +3) as a function of assertion type for majority statistical and striking items in Experiment 1.

not represented via principled connections between the kind and the property.

2.3.6. Can generic acceptance be dissociated from prevalence?

In keeping with the claims made by linguists and philosophers we found that generic acceptance can be dissociated from prevalence. Striking property bare plural generics (e.g., "pitbulls maul children") were accepted to the same extent as majority statistical bare plural generics (e.g., "cars have radios") (1.27 and 1.23 respectively, $t(27) = .34$, $p = .74$, $d = .05$; see Table 3). However, the prevalence estimates associated with the former were significantly lower than the latter (33.13% and 67.97% respectively; $t(11) = 10.34$, $p < .0001$, $d = 4.37$). Furthermore, we also found that both majority statistical bare plural generics and striking property bare plural generics were accepted significantly more than were majority false generalizations in bare plural form (e.g., "books are paperbacks") (1.23, 1.27 and −.06 respectively, $ts(27) > 7.73$, $ps < .0001$, $ds > 1.52$). However, majority statistical and majority false generalizations did not differ in their prevalence estimates (67.97% and 64.39% respectively), and striking property predications had significantly lower prevalence estimates (33.13% vs. 64.39%, $t(11) = 8.25$, $p < .0001$, $d = 3.11$).

2.3.7. Are generics understood as making claims about normal instances?

Our results suggest that this is not the case. The assertion *All normal xs are p* received a relatively high rating for the majority characteristic predications (e.g., "all normal tigers have stripes"). Nevertheless, this rating was lower than the corresponding bare plural generic (e.g. "tigers have stripes") (2.09 vs. 2.48, $t(54) = 2.03$, $p < .05$, $d = .54$). The "all normal" assertion received much lower ratings and was significantly worse than the corresponding bare plural for the majority statistical (e.g., "all normal cars have radios" vs. "cars have radios"), minority characteristic (e.g., "all normal lions have manes" vs. "lions have manes"), and striking property items (e.g. "all normal pitbulls maul children" vs. "pitbulls maul children"), $ts(54) > 4.59$, $ps < .0001$, $ds > 1.23$), with especially low ratings for the striking property predications in "all normal" form. Further, the ratings for *an x is supposed to be p* also differed significantly from the ratings of the bare plural statements for striking property (e.g., "a pitbull is supposed to maul children"), $t(53) = 5.07$, $p < .0001$, $d = 1.36$, and majority statistical predications (e.g., "a car is supposed to have a radio"), $t(53) = 3.56$, $p < .001$, $d = .95$. These data provide evidence against the normalcy approaches to generics.

2.3.8. Cue validity and striking property generics: Is high cue validity needed for licensing low prevalence generics?

The answer to this question is No. High cue validity is not a necessary condition for licensing low-prevalence generics. There are two ways in which Experiment 1 provides data concerning the viability of the cue validity proposal. First, the fact that a stimulus set could be constructed wherein the cue validity of the low prevalence striking property items (e.g., "pitbulls maul children") and the majority statistical items (e.g., "cars have radios") does not differ, where both sets of generics equally acceptable despite the large and significant difference in prevalence, speaks against the idea that low prevalence generics are only possible if their cue validities are much higher than those of generics that are licensed by high prevalence (majority statistical generics). The cue validities for both conditions were not particularly high (.62 and .97 on a scale that ranges from −3 to +3), so the results are unlikely to be due to a threshold effect wherein the cue validities are high enough to license any generic. More dramatically, the majority false generalizations (e.g., "Canadians are right-handed") were also matched to the striking property items on cue validity (.68 vs. .97, $t(11) = .85$, $p = .41$, $d = .31$), but had significantly higher prevalence estimates associated with them (64.39% vs. 33.13%, $t(11) = 8.25$, $p < .0001$, $d = 3.11$). Striking property generics were nonetheless accepted significantly more than the majority false generalizations, as reported above. Because the items were not randomly selected, these data can only be taken to show that it is empirically possible for cue validity and prevalence to be dissociated.

A second way to address the cue validity proposal is to perform a median split on the cue validities of the (low prevalence) striking property items to see if the acceptability of the generic differs for the low and high cue validity items. The split yielded a set of items with mean cue validities of .52 and 1.4, which are significantly different from one another, $t(10) = 4.39$, $p < .005$, $d = 2.54$, and mean prevalences of 34.2 and 32.0, which do not differ statistically, $t(10) = .54$, $p = .60$, $d = .31$. Importantly, there was no hint of a difference in the acceptability of the generics (1.49 vs. 1.51) corresponding to each group, $t(10) = .29$, $p = .78$, $d = .17$. These data suggest that low prevalence generics are licensed by something other than high cue validities.

2.4. Discussion

The results of Experiment 1 confirmed that majority characteristic and majority statistical generics involve principled and statistical connections, respectively. It also provided evidence that striking property generics such as "pitbulls maul children" are not represented via principled connections. Instead, they pattern like majority statistical predications (e.g., "cars have radios"), and not like majority characteristic generics (e.g., "tigers have stripes"). In additon, Experiment 1 found that minority characteristic generics (e.g., "lions have manes") received higher ratings on the relevant principled connection measures than the majority statistical generics did, even though the minority characteristic items had *lower* prevalence ratings than the majority statistical items. This result provides strong evidence that ratings on the principled connection measures are not simply a function of prevalence. It also suggests that minority characteristic generics do not involve statistical connections. Minority characteristic items also differed from majority characteristic items: minority characteristic predications displayed a pattern of responses that suggests they are represented via principled connections, but not to the same extent as majority characteristic predications.

This result can be understood in two ways. First, minority characteristic generics may involve yet another kind of connection between kinds and properties. Alternatively, minority characteristic generics may well involve principled connections, but our dependent measures were affected by factors other than connection type. We favor the latter interpretation. The obvious additional factor that likely contributed to the difference in ratings between majority and minority characteristic predications is the prevalence of the property. Participants clearly know that roughly half the instances do not have the property for the minority characteristic predications, and that knowledge may have influenced their judgments. Prasada and Dillingham (2006, 2009) found that while principled and statistical connections cannot be distinguished on the basis of prevalence, prevalence nonetheless has a small but significant effect on participants' judgments (see also Khemlani et al., 2012). Experiment 1 appears to have yielded a similar result.

Overall, our results show that principled connections underlie minority characteristic generics. This suggests that the statistical dimension of principled connections (at most) grounds the *expectation* that most instances will have the property, but does not require that most instances have the property.

One might note that our examples of minority characteristic generics all involved properties that are only had by one sex. How important is this sex-specificity in shaping people's judgments? That is, suppose that half the members of an animal species, *regardless of sex*, had, e.g., manes while the others did not. Would people understand the connection between this kind and the property of having a mane differently than they understand the connection between lions and the property of having a mane? Real-world examples of this sort are not readily available, and since our items drew on real-world knowledge, we could not directly examine this question here. However, a recent study using novel animal kinds suggests that people do not differentiate between these two cases, at least when it comes to accepting bare plural generics (Cimpian et al., 2010). Thus we cautiously speculate that sex-specificity is not especially important in shaping people's judgments – rather it just so happens that, as a matter of biology, real-world examples have this character.

Experiment 1 also provided evidence for the claim in the semantics literature that generics can be rejected despite high prevalence, and conversely, that they can be accepted despite low prevalence. However, we also found that people accepted the claim that all normal members of a category have a property (or are supposed to have a property) only for the majority characteristic generics. This suggests that normalcy approaches to generics cannot account for the full range of generic beliefs. We also found results that contravene the idea that cue validity licenses low prevalence generics. We found that the (low prevalence) striking property generics were accepted even though they did not have particularly high cue validity estimates associated with them. Further, the striking property generics with the highest cue validity ratings were not more likely to be accepted than the ones with the lowest cue validity ratings.

3. Experiment 2: Which types of generics support formal explanations?

Experiment 1 provided an indirect measure of the explanatory dimension of principled connections via judgments about whether different predication types are supported a "by virtue of" assertion. Experiment 2 sought to investigate whether the connections that underlie the kinds and properties in striking and minority characteristic generics explicitly support formal explanations. In this experiment, participants were presented with a question (Q) that asked why an instance of a kind had a given property. They then rated the naturalness of an answer (A) that explained the property's presence via reference to the kind of thing it was along with the basis for the explanation (that the property is one aspect of being that kind of thing). By specifying the basis for why reference to the kind is explanatory, the experiment ensured that participants rated the acceptability of formal explanations rather than some other type of explanation that may be implicitly deployed by reference to the kind of thing something is. Formal explanations for items that involve principled connections, such as example (1) below, should yield high ratings, however, when a statistical connection is involved, as in (2), formal explanations should receive low ratings (Prasada & Dillingham, 2006).

(1) Q: Why does that (pointing to a tiger) have stripes?
A: Because it is a tiger, and having stripes is one aspect of being a tiger.
However,

(2) Q: Why does that (pointing to a car) have a radio?
A: Because is a car and having a radio is one aspect of being a car.

Consequently, we expect that formal explanations involving majority characteristic items (e.g., "tigers have stripes") would receive higher ratings than formal explanations involving majority statistical items (e.g., "cars have radios"). Based on the results of Experiment 1, we further expected that formal explanations involving minority characteristic predications (e.g., "lions have manes") would be rated more highly than those involving majority statistical predications. We also expected formal explanations for majority characteristic items to receive higher ratings than those for minority characteristic items. Finally, we expected that formal explanations involving striking property predications (e.g., "pitbulls maul children") would not be rated more highly than those involving majority statistical items (e.g., "cars have radios").

3.1. Method

3.1.1. Participants

Twenty five volunteers from the same participant pool as in Experiment 1. All spoke English as their first language, and none had participated in experiments concerning generics before.

3.1.2. Materials and design

We used the experimental items from Experiment 1 to generate question–answer pairs such as (1). The false generalization items from Experiment 1 were included as fillers. The materials generated a one-way repeated measures design. Each participant received the items in a different random order.

3.1.3. Procedure

Participants evaluated the extent to which the responses to the questions sounded natural on a 7-point Likert scale.

3.2. Results and discussion

Participants' responses on the Likert scale were given numerical values from −3 (very bad) to +3 (very good). The mean responses are given in Table 5. As with Experiment 1, a Hartigan's dip test on the data from the trials with the minority characteristic predications revealed no tendency for the data to be bi-modal ($p > .5$).

We found a significant effect of predication type, $F_1(3,72) = 56.52$, $p < .0001$, $F_2(3,63) = 58.79$, $p < .0001$, min $F'(3,110) = 28.82$, $p < .0001$. Planned t-tests revealed that, as predicted, formal explanations involving majority characteristic predications (e.g., "tigers are striped") received higher ratings than formal explanations involving majority statistical items (e.g., "cars have radios") $t_1(24) = 10.03$, $p < .0001$, $t_2(11) = 7.94$, $p < .0001$. This result essentially replicates the findings of Prasada and Dillingham (2006). More importantly, formal explanations involving minority characteristic predications (e.g., "lions have manes") also received higher ratings than formal explanations involving majority statistical predications, $t_1(24) = 7.28$, $p < .0001$, $t_2(11) = 6.81$, $p < .0001$. As with Experiment 1, we ran an analysis comparing the minority characteristic items to only the natural kind majority statistical items. We found the same pattern of results. These results add to the evidence from Experiment 1 that minority characteristic generics are represented via principled connections.

On the other hand, formal explanations involving striking property predications (e.g., "pitbulls maul children") did not receive significantly higher ratings than formal explanations involving majority statistical items (e.g., "cars have radios"). In fact, they were marginally lower in the participant analysis, $t_1(24) = 1.81$, $p = .08$, $t_2(11) = 1.38$, $p = .19$. Finally, the ratings for the formal explanations involving minority characteristic predications (e.g., "lions have manes") received lower ratings than formal explanations involving majority characteristic predications (e.g., "tigers have stripes"), $t_1(24) = 3.55$, $p < .005$, $t_2(11) = 4.23$, $p < .005$. This was also the case when only the natural kind majority characteristic items were included in the analysis. This result suggests that factors other than connection type (most likely prevalence) can contribute to the dependent measure.

Table 5
Mean judgments of naturalness (−3 to +3) for the question–answer pairs provided in Experiment 2 as a function of predication type.

Predication type	Naturalness judgment to question–answer pair
Majority characteristic	1.69
Minority characteristic	1.12
Majority statistical	−.31
Striking	−.65
Filler items	
Majority false generalization	−1.44

Experiments 1 and 2 suggest that majority characteristic and minority characteristic generics both involve principled connections and that neither striking property nor majority statistical generics do so. This raises the question of whether striking property and majority statistical generics may both involve statistical connections, or whether striking property generics involve a different type of connection between kinds and properties. The fact that striking property generics are accepted as true despite the low prevalence of their properties strongly suggests that striking property generics do not involve mere statistical connections. Leslie (2007, 2008, in press) and Prasada (2010) suggest that striking property generics involve a causal connection between a kind of thing and the property in question, in the sense that, e.g., the biological make-up of ticks causes them to be disposed to carry Lyme disease. It is not enough that a few members of the kind *happen* to have the striking property – rather there must be something about the nature of the kind that causally grounds the presence of the property. Where there is a mere statistical connection, on the other hand, the attribution of a causal connection sounds infelicitous (e.g., even though "dogs wear collars" is judged as true, there is nothing about being a dog that causes it to wear a collar).

4. Experiment 3a: Do striking property generics involve causal connections?

To assess whether striking property generics, but not majority statistical generics, involve a causal connection between the kind and property, we asked participants to judge assertions of the form, "There is something about Ks that causes them to P". If striking property generics involve causal connections, then participants will accept the assertion of a causal connection for striking predications but not for majority statistical predications.

4.1. Method

4.1.1. Participants

Twenty volunteers from the same participant pool as in the previous experiments. All spoke English as their first language. None had participated in experiments concerning generics before.

4.1.2. Materials and design

Experiment 3a used the striking and majority statistical items used in the previous experiments. Each item was used to generate a statement involving a causal connection (e.g., "There is something about cars that causes them to have radios”). The materials generated a one-way repeated measures design.

4.1.3. Procedure

Participants evaluated the extent to which the statement struck them as being definitely true (+3) or definitely false (-3) on a 7-point Likert scale.

4.2. Results and discussion

Participants rated striking items significantly higher ($M = 1.77$) than the majority statistical items ($M = .48$), $t_1(19) = 5.77$, $p < .0001$, $d = 1.16$, $t_2(11) = 4.10$, $p < .005$, $d = 1.66$. Furthermore, 18 out of 20 participants accepted the striking property predications more often than majority statistical predications in the causal formulation (Binomial test, $p < .0005$). This finding supports the idea, put forward in Leslie (2007, 2008, in press) and Prasada (2010), that striking property generics are understood as involving a causal connection between the kind and the property. Even though very few mosquitoes actually carry malaria, people still believe that there is a causal connection between mosquitoes and malaria – i.e. that there is something about mosquitoes that causes them to carry malaria. No such connection need exist between a kind and a merely statistically prevalent property.[6]

5. Experiment 3b: What mediates causal connections of striking generics?

There are many sorts of causal chains, and so we sought to specify the nature of the causal connection that is thought to hold between a kind and a striking property. Striking properties appear to come about as a result of the underlying physical, material, and functional organization of the kind in question. To test this idea, we asked participants to judge assertions of the form “The parts and functional organization of Ks cause them to be P”. While stilted, this statement provides a relatively straightforward way of capturing the relevant intuition in a manner that can be applied across a broad range of items.

5.1. Method

5.1.1. Participants

Eighteen volunteers from the same participant pool as in the previous experiments. All spoke English as their first language and none had participated in experiments concerning generics before.

5.1.2. Materials and design

Same as Experiment 3a except that the statement rated by participants was “The parts and functional organization of Xs cause them to be Y”.

[6] It should be noted that, although we have often used inanimate examples for majority statistical generics and animate examples for striking generics, our stimuli for each category included roughly even numbers of animate and inanimate examples (see Appendix A).

5.1.3. Procedure

Same as Experiment 3a.

5.2. Results and discussion

Participants rated striking items significantly higher ($M = 1.01$) than the majority statistical items ($M = .08$), $t_1(17) = 4.15$, $p < .001$, $d = .69$, $t_2(11) = 3.67$, $p < .005$, $d = 1.35$. Furthermore, 16 out of 18 participants accepted the striking predications more often than majority statistical predications in the causal formulation (Binomial test, $p < .005$).

The results of Experiments 3a and 3b suggest that striking property generics involve representing a causal connection between the kind and the property, and that striking properties are understood to be causally connected to the parts and functional organization of instances of the kind. This causal connection grounds the intuition that the striking properties are systematically related to the nature of the kind. As with all causal connections, how often an effect (the striking property) is actually realized depends on how often the relevant enabling conditions are present and preventative conditions are absent. As such, the causal connection grounds the truth of striking property generics even though the striking property may be rarely realized because the relevant enabling conditions may be quite rare. Generics involving principled connections (majority and minority characteristic generics) would likely receive high ratings on the measures used in Experiments 3a and 3b, indicating that these generics also involve causal connections. However, principled connections cannot simply be causal connections because, as Experiments 1 and 2 show, striking property generics, which involve causal connections, do not support (i) formal explanations, (ii) normative expectations, (iii) “by virtue” assertions, or (iv) understanding striking properties as aspects of the relevant kind of thing.

6. General discussion

Experiments 1 and 2 provided evidence that minority characteristic generics (e.g., “lions have manes”) and majority characteristic generics (e.g., “tigers have stripes”) involve principled connections, while striking property generics (e.g., “pitbulls maul children”) and majority statistical generics (e.g., “cars have radios”) do not. Minority characteristic generics behave more like majority characteristic generics on measures designed to test the presence of principled connections than do majority statistical generics (even though the minority characteristic generics have a *lower* prevalence than the majority statistical generics). This result strongly suggests that an account based on prevalence alone cannot distinguish between principled and statistical connections. Experiment 1 also found that striking property predications were accepted as true in the bare plural form even though the prevalence of the properties in question was estimated to be very low among members of the kind. Conversely, participants rejected generics such as “books are paperbacks” and “Canadians are right-handed” (i.e., majority false generalizations) even though they involve properties that are possessed by the majority of the members of the kind. These findings confirm some claims that have been made in the semantics literature, and provide further evidence that generics cannot be understood to be simply making vague quantificational assertions (Carlson, 1977; Lawler, 1973; Leslie, 2007, 2008). Instead, different types of generics involve distinct ways in which we connect kinds and properties (Prasada & Dillingham, 2006, 2009).

Experiment 3 provided evidence that striking property generics, but not majority statistical generics, involve a causal connection between the kind and property. Together, the experiments suggest that our conceptual systems provide at least three ways (principled, causal, and statistical) of representing the connection between a kind and a property. They thus provide evidence for Leslie's (2007, 2008) claim that there are three fundamental ways of generalizating information within our conceptual systems: one pertaining to the generalizations that underlie generics that involve majority and minority characteristic predications; one pertaining to the generalizations that underlie generics that involve striking predications; and one pertaining to the generalizations that underlie generics that involve majority statistical predications. These three modes of generalization are proposed by Leslie (2007, 2008) to be our default modes of generalization. They may, as a consequence, appear earlier in cognitive development than explicitly quantificational generalizations which involve set-theoretic notions (see Leslie, 2012, for a review). In what follows, we (i) discuss each connection type and its features, (ii) consider the implications of our findings for formal semantic approaches to generics, (iii) consider what these three connection types reveal about our conceptual systems, and (iv) identify some questions for future research.

6.1. Three types of connections

6.1.1. Principled connections

Prasada and Dillingham (2006, 2009) proposed that principled connections have an explanatory, a normative, and a statistical dimension, and provided evidence that representing a property as having a principled connection to a kind requires representing it as being an aspect of being that kind of thing. Data from Experiments 1 and 2 help to elaborate our understanding of principled connections by showing that both minority characteristic generics and majority characteristic generics support formal explanations and display a normative dimension. These findings extend the scope of principled connections. Previous research had considered only majority characteristic properties. That minority characteristic predications involve principled connections suggests that principled connections do not *require* high statistical prevalence, but we would argue nonetheless that, if a principled connection is represented, then people *expect* the property to be statistically prevalent. This expectation, while sometimes violated, helps explain some otherwise puzzling findings. For example, Khemlani, Leslie and Glucksberg's (2009, 2012) finding that 85% of people who accepted the generic "ducks lay eggs" also agreed to "Quacky lays eggs" when told only that Quacky is a duck. Further, the prevalence estimates that we collected reflect a tendency to overestimate the prevalence of minority characteristic predications (see also Khemlani et al., 2009; Khemlani, Leslie, Glucksberg, & Rubio-Fernandez, 2007; Leslie, Khemlani, & Glucksberg, 2011). These findings would all be explained by the hypothesis that principled connections support the *expectation* of statistical prevalence, even though this expectation is sometimes violated.

6.1.2. Causal connections

Experiment 3 provided evidence that striking property generics involve a causal connection between the kind and the property. Experiments 1 and 2 showed that striking property generics do not support formal explanations or normative expectations, and thus suggest that causal connections need not support formal explanations or normative expectations.[7] We hypothesize that causal connections also do not support expectations concerning prevalence. The prevalence of the property is determined by the prevalence of relevant enabling conditions and the absence of relevant prohibiting conditions. How often such circumstances occur is not determined by the kind in question, nor by the causal connection between the kind and the property.

6.1.3. Statistical connections

Finally, there is a class of generics that involve merely statistical connections between the kind and property. These connections support neither formal explanations, normative expectations, nor causal statements concerning the property in question. Though the connection is justified on a statistical basis, we do not currently know the statistical principle(s) by which our conceptual systems decide that the connection observed in a limited sample of instances may be generalized to the indefinitely many instances that constitute the kind (Prasada, 2010).

As Leslie (2007, 2008; following Carlson, 1977; Carlson & Pelletier, 1995) notes, statistical prevalence alone is not enough for a generic to be accepted. Data from Experiment 1 confirmed this. The prevalence estimates for false generalizations (e.g. "books are paperbacks", "Canadians are right-handed") were high, yet they were consistently rejected in bare plural generic form. Leslie (2007, 2008) suggests that these generics are rejected because the exceptions to the generics have salient, positive alternative properties – e.g., the hardcover books, and the left-handed Canadians. Our experiments here did not test this hypothesis, however, since these false generalizations were used only as fillers.

6.2. Formal semantic approaches to generics

Consistent with a number of claims in the semantics literature, we found that generics can be rejected despite

[7] We should emphasize that we are not proposing that the existence of a causal connection between a kind and a property is itself *sufficient* for the generic to be accepted, rather that this class of generics – namely striking generics – involve such a causal connection.

having high associated prevalence estimates, and conversely, they can be accepted despite having low associated prevalence estimates. However, some of our other findings are at odds with many of the semantic accounts of generics that have been proposed. In particular, many accounts cluster together under what we have called "normalcy" approaches to generics (e.g., Asher & Morreau, 1995; Dahl, 1975; Krifka et al., 1995; Nickel, 2008; Pelletier & Asher, 1997). These accounts differ in their details, but share a common commitment to the idea that generics are only true if it is *normal* for the members of the kind to have the property in question. There have been several theoretically-based critiques of this approach (e.g., Cohen, 1996; Leslie, 2007, 2008). However no prior empirical work had tested the proposal directly. We found that people consistently judge that all normal members of the kind have the property and also that members of the kind are supposed to have the property only in the case of majority characteristic generics – such as "tigers are striped" – which are often the only examples discussed by proponents of the normalcy approach. Majority statistical and striking property items were accepted in bare plural generic form, but not in the *all normal* or *supposed to* formulations. This suggests that normalcy approaches cannot account for the full range of generic beliefs.

We also found that striking property generics are accepted despite having low associated prevalence estimates. However, the striking property generics did not have particularly high cue validity estimates associated with them, and further, the striking property generics with the highest cue validity ratings were not at all more likely to be accepted than the ones with the lowest cue validity ratings. This suggests that cue validity does not explain why low prevalence generics are accepted. Instead, the results of the present experiments suggest that low prevalence striking property generics may involve a causal connection between a kind and a property. The present research thus identifies a number of limitations of formal semantic approaches to generics that seek to provide a general account of generics in terms of notions such as prevalence, normalcy, and cue validity.

6.3. Generics and conceptual representation

Our findings have important implications for the manner in which conceptual knowledge is represented. Research inspired by prototype theories of conceptual representation has focused attention on the probabilistic nature of much of our conceptual knowledge, and thus emphasized the role of statistical connections in conceptual representation (e.g. McRae, de Sa, & Seidenberg, 1997; Rogers & McClelland, 2004; Tyler & Moss, 2001; Yoshida & Smith, 2003). On the other hand, research within the theory-based approach to conceptual representation has focused attention on the explanatory nature of much of our conceptual knowledge, and has emphasized the role of causal knowledge and causal connections in conceptual representation (e.g. Carey, 1985; Gelman, 1990, 2003; Keil, 1989; Rehder, 2009; Sloman, Love & Ahn, 1998). Though these two approaches are often discussed as if they are mutually exclusive, a number of researchers have argued for hybrid theories of conceptual representation whereby conceptual knowledge is constituted by causal/explanatory as well as statistical knowledge (Gelman, 1990; Keil, 1989; McNorgan, Kotack, Meehan, & McRae, 2007; Sloman et al., 1998).

The present work suggests the need for another dimension to conceptual knowledge — namely the formal dimension that involves principled connections. Prasada and Dillingham (2009) provided evidence that representing a principled connection between a kind and a property involves representing the property as an aspect of being that kind of thing. As such, principled connections involve representing a specific type of part-whole relation between the property and the kind of which it is an aspect. Thus, our knowledge of kinds and their properties seems to have a formal dimension which complements the causal and statistical dimensions investigated in previous research on conceptual representation (see Prasada & Dillingham, 2009 for a more detailed characterization of aspect and kind representations).

Generics reflect the three perspectives we can take when thinking and reasoning about kinds of things. We can focus on the formal dimension by attending to principled connections. In doing so, we notice certain formal explanatory relations as well as the basis for certain normative and statistical expectations. Alternatively, we can focus on the material dimension by attending to the material constitution of the instances and thus their causal dispositions to behave in one or another manner in appropriate circumstances. Finally, we may adopt a perspective where we do not attend to either the formal or material characteristics of instances of a kind, but simply note the statistical connections that exist between instances of the kind and various properties.

Although we have distinguished the different connection types using different kinds and properties, we do not mean to imply that only a single connection type is represented between a given kind and a given property. There may be cases in which we represent multiple connections between a specific kind and property. For example, it is likely that we represent all three types of connections between the kind *dog* and the property of *having four legs*. As previous research and the present experiments show, each connection type grounds different kinds of linguistic and nonlinguistic phenomena, and thus it does not seem that connection types are reducible or replaceable by one another.

Finally, the types of connection properties have to kinds need to be distinguished from the centrality or mutability of the property (Sloman et al., 1998). For example, there is a principled connection between being a canary and being yellow even though being yellow is not a causally central property of canaries. Similarly, it is easy to change the number of legs of a dog, or the color of a banana, or the crunchiness of a carrot, and leave their identity and most of their properties intact even though these properties have a principled connection to the kinds in question. More generally, though there may be tendencies for properties with statistical connections to be less causally central and more mutable than properties that have principled or causal connections to a kind, we do not think it is possible to replace the notion of connection types with information about feature centrality or mutability. In our opinion, conceptual representations of kinds will represent information about the types of connections that exist between the kind and the property as well as information concerning the centrality or mutability of the property for that kind (see Prasada & Dillingham, 2006, 2009 for further discussion).

6.4. Summary and directions for future research

The experiments in this paper flesh out the conceptually based approach to generics by providing evidence that minority characteristic predications involve principled connections, that striking property predications involve causal connections between kinds and properties, and that principled connections ground an expectation rather than a requirement of high prevalence. The experiments also provide data that are problematic for normalcy approaches to generics and for the idea that cue validity licenses low prevalence generics. Thus they provide further reasons for pursuing the conceptually based approach to the semantics of generics (Leslie, 2007, 2008; see also Carlson, 2009).

The present research also suggests a number of directions for future investigation. By identifying the distinct types of connections we represent between kinds and properties, the present research helps clarify the nature of the acquisition problems faced by children. In acquiring generic knowledge, children must not only figure out which properties to generalize to the kind, they must also figure out what type of generalization (connection type) is involved. An interesting question for future research concerns the developmental time course of distinct forms of generic knowledge—does generic knowledge involving one of the connection types develop earlier than the other connection types? Another important goal for future research will be to determine how linguistic cues might help children with this problem. Though it is well known that principled and statistical generics show somewhat different linguistic profiles (specifically, only principled connections support indefinite singulars such as "a tiger is striped"; Lawler, 1973; Leslie et al., 2009), the question of how generics involving causal connections may be expressed linguistically has not been systematically studied. It will also be important to investigate how the distinct ways in which properties are connected with kinds impact inductive and default reasoning (Khemlani et al., 2009, 2012). Finally, the present research raises the question of whether multiplicities that are not construed as kinds (e.g. white bears) can also be characterized via principled, statistical and causal connections (Prasada, 2012; Prasada & Dillingham, 2006; Prasada, Hennefield, & Otap, 2012).

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Appendix A. Norming study and materials for Experiments 1, 2, and 3

A total of 84 kind-predicate pairs (tigers-striped) were needed for the studies, 12 for each of the seven types of predication used in the experiments as experimental and filler items. We sought to hold cue validity, the probability that an item is part of a category given a particular cue, constant for the five types of predication. We further sought to balance levels of agreement and estimates of prevalence for several of the predicate types. To do this, we conducted a norming study ($N = 62$) in which participants evaluated 210 different items of varying predication types. Participants were randomly assigned to perform one of three tasks. Participants who performed Task 1 (the agreement task) were asked to judge the truth of a statement in bare plural form (e.g., "Tigers are striped"). They registered their answer on a 7-point scale ranging from +3 (definitely true) to −3 (definitely false). Participants who performed Task 2 provided prevalence estimates, i.e., they provided an integer from 1 to 100 to the question, "What percentage of tigers are striped?" The instructions emphasized that the estimates should reveal the percentage of individuals of the kind that have the property (individual tigers that have stripes) rather than the percentage of kinds of tigers (e.g. Bengal tigers, White tigers) that have the property. Participants were also told that they should interpret the kind terms as referring to all instances of the kind, rather than just a subset if a term (e.g. *lion*) could be used in either way. Task 3 asked participants to judge, i.e., they were told, "Suppose x has stripes. How likely is it that x is a tiger?" Participants registered their answer on a 7-point scale ranging from +3 (very likely) to −3 (very unlikely). Of the 210 items that were evaluated, we chose 84 items based on the factors outlined above. Those items are provided in Table A, along with their corresponding agreement ratings, cue validity estimates, and prevalence estimates.

Table A
Truth judgments (+3 to −3), cue validity estimates (+3 to −3), and prevalence estimates (0–100%) for materials used in Experiments 1, 2, and 3 as a function of predicate type.

Predication type	Item	Kind	Truth judgment	Cue validity estimate	Prevalence estimate
Majority characteristic	Airplanes have wings	Artifact	2.91	.11	95.32
	Scissors cut	Artifact	2.67	1.00	91.89
	Ambulances have sirens	Artifact	2.50	1.47	89.11
	Needles are sharp	Artifact	2.42	.42	88.74
	Tables are flat	Artifact	2.29	.05	87.95
	Diapers are absorbent	Artifact	2.65	.42	87.58
	Horses have four legs	Natural	2.54	−.11	94.58
	Birds have wings	Natural	2.63	1.58	94.11
	Lemons are sour	Natural	2.25	1.06	91.42
	Leopards have spots	Natural	2.17	.68	88.32
	Dogs have tails	Natural	2.42	−.21	87.16
	Feathers are light	Natural	2.29	.44	86.16
		Mean	2.48	.58	90.19
Minority characteristic	Sheep produce milk	Natural	2.00	−.06	51.89
	Lions have manes	Natural	1.46	.89	53.63
	Deer have antlers	Natural	1.09	1.05	54.21
	Ducks lay eggs	Natural	2.04	.58	56.53
	Elk have antlers	Natural	1.67	.42	57.00
	Cows have udders	Natural	2.04	1.33	57.74
	Moose have antlers	Natural	1.79	.67	60.21
	Pigs suckle their young	Natural	1.54	−.53	60.95
	Goats have horns	Natural	1.42	.11	62.53
	Snakes lay eggs	Natural	2.00	.32	63.68
	Kangaroos have pouches	Natural	2.33	1.26	64.89
	Peacocks have beautiful tails	Natural	1.91	1.32	64.63
		Mean	1.77	.61	58.99
Majority statistical	Trumpets are loud	Artifact	1.38	−.11	79.47
	Fire trucks are red	Artifact	1.92	.84	75.47
	Cars have radios	Artifact	1.46	.79	74.74
	Dolls wear dresses	Artifact	1.04	.47	68.74
	Diapers are white	Artifact	.83	−.79	78.79
	Rocking chairs are wooden	Artifact	.83	−.26	71.21
	Cats like milk	Natural	2.21	.67	74.21
	Dogs bark at strangers	Natural	1.75	2.37	62.05
	Eggshells are white	Natural	1.75	.21	59.79
	Summers are humid	Natural	1.21	1.16	58.89
	Winters are snowy	Natural	1.29	1.58	57.58
	Raccoons eat garbage	Natural	1.13	.53	54.74
		Mean	1.40	.62	67.97
Striking	Lead toys poison children	Artifact	1.79	.89	43.42
	Knives cut people	Artifact	1.63	.78	34.47
	Rusty nails cause tetanus	Artifact	1.50	1.26	33.32
	Car crashes kill people	Artifact	1.48	.21	34.00
	Guns kill people	Artifact	1.38	.37	33.32
	Plastic bags suffocate small children	Artifact	1.38	.89	25.89
	Rip tides drown swimmers	Natural	1.67	1.26	21.21
	Mosquitoes carry malaria	Natural	1.63	2.05	25.63
	Loud noises deafen people	Natural	1.46	1.37	32.32
	Ticks carry Lyme disease	Natural	1.42	1.37	46.00
	Snow storms shut down schools	Natural	1.39	1.22	33.63
	Strokes kill people	Natural	1.25	−.05	34.32
		Mean	1.50	.97	33.13
Quasi-definition	Cats are animals	Natural	2.42	.17	91.74
	Mushrooms are fungi	Natural	2.46	1.47	90.11
	Rectangles are geometric figures	Natural	2.54	.72	89.84
	Even numbers are divisible by 2	Natural	2.21	2.58	89.05
	Kangaroos are marsupials	Natural	2.33	1.37	86.26
	Ants are insects	Natural	2.83	.72	85.63
	Dogs are mammals	Natural	2.00	−.06	80.79
	Sows are pigs	Natural	1.74	.58	80.37
	Elms are trees	Natural	2.54	−.05	78.42
	Bachelors are unmarried	Social	2.63	1.32	84.11
	Preschoolers cannot vote	Social	2.13	.26	91.58
	US Presidents are over 35	Social	2.74	−.68	87.26
		Mean	2.38	.70	86.26

Table A (*continued*)

Predication type	Item	Kind	Truth judgment	Cue validity estimate	Prevalence estimate
Majority false generalization	Books are paperbacks	Artifact	.21	1.68	59.84
	Computers are pcs	Artifact	1.54	2.58	64.37
	Bees are worker bees	Natural	.96	1.72	81.84
	Ducks are female	Natural	−.58	−.74	49.26
	Humans are over 3 years old	Natural	.00	.32	82.53
	Lions are male	Natural	−.04	−.16	57.11
	Mammals are placental mammals	Natural	.92	1.89	69.21
	Trees are deciduous trees	Natural	.50	1.84	45.79
	Canadians are right-handed	Social	−.50	−.95	74.89
	Engineers are male	Social	.04	−.42	72.79
	Teachers are female	Social	−.26	.16	65.21
	Americans are brunettes	Social	−.21	.21	49.84
		Mean	.21	.68	64.39
Minority false generalization	Cars are yellow	Artifact	−.50	−.21	22.84
	Houses are mansions	Artifact	−.21	2.05	15.63
	Novels are mystery novels	Artifact	.04	1.74	29.95
	Restaurants are Chinese restaurants	Artifact	−.91	2.42	27.42
	Rooms are round	Artifact	−.58	−1.21	19.16
	Tables are 10 feet long	Artifact	−.67	.05	19.63
	Cats are white	Natural	−.67	−.26	20.63
	Dogs are beagles	Natural	−.88	2.00	21.37
	Mammals are hamsters	Natural	−.54	1.47	15.47
	Plants are ferns	Natural	.04	2.00	17.37
	Tigers are albino	Natural	−.88	−.37	16.84
	Trees are palm trees	Natural	−.48	1.94	13.79
		Mean	−.52	.97	20.01

Appendix B. Summary of the planned *t*-tests for Experiment 1 ($N = 137$)

			Participant analysis		Item analysis	
Assertion type	Mean 1	Mean 2	t_1	p	t_2	p
1. Majority characteristic vs. majority statistical						
	Majority characteristic	Majority statistical				
Bare plural	2.48	1.23	$t(54) = 7.25$	<.0001	$t(22) = 9.82$	<.0001
Aspect	2.40	.57	$t(50) = 6.44$	<.0001	$t(22) = 9.04$	<.0001
All normal	2.09	−.10	$t(54) = 7.26$	<.0001	$t(22) = 8.12$	<.0001
By virtue	2.25	.02	$t(54) = 8.46$	<.0001	$t(22) = 12.00$	<.0001
Normative	2.40	.19	$t(52) = 7.87$	<.0001	$t(22) = 9.92$	<.0001
2. Minority characteristic vs. majority statistical						
	Minority characteristic	Majority statistical				
Bare plural	1.83	1.23	$t(54) = 3.02$	<.019	$t(22) = 4.62$	<.0007
Aspect	1.48	.57	$t(50) = 2.83$	<.033	$t(22) = 3.54$	<.009
All normal	.34	−.10	$t(54) = 1.29$	>.50	$t(22) = 1.28$	>.50
By virtue	1.28	.02	$t(54) = 4.60$	<.0001	$t(22) = 5.85$	<.0001
Normative	1.40	.19	$t(52) = 3.72$	<.003	$t(22) = 4.32$	<.001
3. Majority characteristic vs. minority characteristic						
	Majority characteristic	Minority characteristic				
Bare plural	2.48	1.83	$t(54) = 3.95$	<.001	$t(22) = 4.74$	<.0005
Aspect	2.40	1.48	$t(50) = 3.99$	<.001	$t(22) = 4.24$	<.002
All normal	2.09	.34	$t(54) = 6.16$	<.0001	$t(22) = 6.40$	<.0001
By virtue	2.25	1.28	$t(54) = 3.86$	<.002	$t(22) = 4.80$	<.0004
Normative	2.40	1.40	$t(52) = 4.52$	<.0002	$t(22) = 4.02$	<.003
4. Striking vs. majority characteristic						
	Striking	Majority characteristic				
Bare plural	1.27	2.48	$t(54) = 6.39$	<.0001	$t(22) = 9.84$	<.0001
Aspect	.76	2.40	$t(50) = 5.63$	<.0001	$t(22) = 9.88$	<.0001
All normal	−1.27	2.09	$t(54) = 12.65$	<.0001	$t(22) = 15.18$	<.0001
By virtue	.28	2.25	$t(54) = 7.25$	<.0001	$t(22) = 11.87$	<.0001
Normative	−.25	2.40	$t(52) = 9.56$	<.0001	$t(22) = 13.25$	<.0001

(*continued on next page*)

Appendix B (*continued*)

			Participant analysis		Item analysis	
Assertion type	Mean 1	Mean 2	t_1	p	t_2	p
5. Striking vs. majority statistical						
	Striking	Majority statistical				
Bare plural	1.27	1.23	$t(54) = .19$	>.50	$t(22) = .37$	>.50
Aspect	.76	.57	$t(50) = .53$	>.50	$t(22) = .85$	>.50
All normal	−1.27	−.10	$t(54) = 3.59$	<.004	$t(22) = 3.88$	<.004
By virtue	.28	.02	$t(54) = .86$	>.50	$t(22) = 1.39$	>.50
Normative	−.25	.19	$t(52) = 1.20$	>.50	$t(22) = 1.85$	>.39

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