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# Representation of Sex-Linked Properties: Implications for Conceptual Representation and Generics

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by

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**Abstract**

Everyone knows that ducks lay eggs and that ducks quack. It is also clear that neither laying eggs, nor quacking is an accidental property of being a duck. They are lawfully connected to being a duck. In fact, both properties are understood to have a principled connection to the kind, duck (Prasada, Khemlani, Leslie & Glucksberg, 2013). Despite these similarities, the representation of knowledge of the sex-linked properties of a kind poses difficult problems for current theories of conceptual representation and how generic knowledge is represented. Theories of conceptual representation seek to represent what is *shared* by instances of a kind, but the sex-linked properties are possessed by half or fewer instances (often only mature, healthy male/female instances). Furthermore, the property appears to be lawfully connected to only instances of one type of instance and thus one would expect the property to only be included in our concept of that type of instance (e.g. female ducks for laying eggs), but not the other type of instance (e.g. male ducks for laying eggs). For the same reason, it seems like the generic *Female ducks lay eggs* should be licensed, but *Ducks lay eggs* should not be licensed, even though it clearly is. Four experiments provided evidence that we represent principled connections between kinds and sex-linked properties such that one type of instance of the kind has a principled connection for the *presence* of the property and the other type has a principled connection for the *absence* of that property. We discuss the implications of the results for theories of conceptual representation and generics.

*Keywords:* Conceptual representation, Kind representations, Generic knowledge, Principled connections

# REPRESENTATION OF SEX-LINKED PROPERTIES: IMPLICATIONS FOR CONCEPTUAL REPRESENTATION AND GENERICS

Categories play a vital role in our understanding of the world around us. Categories simplify the process of incorporating new information by allowing us to generalize and make predictions about a certain population, rather than an individual thing. This allows a person to skip the process of relearning information, and instead categorize and reason about new information using what is already known. If we are presented with an item that we've never seen before, we respond by utilizing the information that we already possess to categorize this never-before-seen item. We use this information to reason about this new item, which in turn guides our expectations regarding how to think and act with this new item. The mental representations that we form regarding categories are referred to as concepts. Categories and concepts act as building blocks for human thought and behavior (Medin, 1989). The process of how categories are represented and organized by individuals is known as conceptual representation (Markman, 2006).

## Thinking and talking about kinds and instances of kinds

Kind concepts refer to categories such as dog, table, or tree, as opposed to a more general category such as "white things" or "round things". Kinds involve a collection of correlated properties and possess a causal structure. (Markman, 2006). Recently, one way that people have been studying how we represent concepts, specifically kind concepts, is by studying generics (Cimpian & Markman, 2009; Gelman, 2009). We naturally think and talk about things as members or instances of kinds. Generic knowledge involves kinds of things. A statement is considered to be generic if it conveys a generalization about the members of a kind, as in "Ducks lay eggs" or "Lions have manes" (e.g., Carlson, 1977; Carlson & Pelletier, 1995; Leslie, 2008). Generics are said to play a vital role in children's conceptual development (Gelman, 2009). Children as young as two and a half years old can comprehend and use generic sentences (e.g., "dogs have four legs") to think and talk about kinds and their instances and the properties that distinguish these kinds (Gelman, 2003).

Generic sentences provide an inside perspective into our conceptual systems and offer insight on the ways in which our conceptual system can represent kinds of things and the connections between kinds and properties that characterize kinds and their instances. Kind representations play a significant role in human thought and language; kind representations can refer to all kinds of entities and range from non-living things, such as a paperclip, to living things, such as a dog. Kind representations "underlie the meanings of most count and mass nouns in natural language, and as such, they provide an important interface between non-linguistic conceptual structure and combinatorial, hierarchical, unbounded linguistically expressible thought" (Haward, Wagner, Careya and Prasada, 2018, p. 255). In linguistics, mass nouns refer to nouns that name something which cannot usually be counted and is referred to in the singular (i.e., air, advice, etc.); count nouns refer to nouns that can usually be counted (i.e., dog, table, etc.) (Wisniewski, Lamb, & Middleton, 2003). Given the significant role that kind representations play in common sense thought and language, research on the acquisition and understanding of characteristics of kinds is a significant aspect of theories of conceptual representation (Gelman, 2003; Prasada, 2016). By utilizing a conceptually based approach to studying generics, and by focusing on the many ways in which our conceptual systems represent connections between kinds and properties, we can uncover domain-general ways in which our concepts of kinds are constructed (Prasada & Dillingham, 2009).

When we talk about things like dogs or tables, we are talking about indefinitely many things that belong to a kind. Rather than listing every single dog or table that exists, we instead refer to them as a single abstract kind, which is understood to contain indefinitely many instances. However, when we talk about one specific dog, we would refer to an instance of the kind. To refer to something as an instance of a kind is to think of it as one of indefinitely many things of that kind (Prasada, 2016). Prasada (2016) has proposed that we have mechanisms for thinking about kinds and instances of kinds. Instances of kind representations have the format illustrated in (1). This can go on indefinitely as each representation (k) in (1) provides us with the means of thinking about each different instance of the same kind. (2) illustrates a generative type-token mechanism for representing the kind, which implicitly contains the representations of indefinitely many instances of the kind (Prasada, 2016).

(1) K1 K2 K3 . . .

(2) Ki

One important aspect of the above kind representations is that they also support the dual, and simultaneous, function of thinking about kinds as instances of a kind, and thinking about kinds, themselves (Prasada, 2016). An example of this is that we can think about Fido the dog as an instance of the kind dog, but we also possess the ability to think about dogs as a kind when we think about dogs, for example, as a kind evolving from wolves as a kind. We are not thinking of individual dogs evolving from individual wolves, but rather the whole category (kind) dogs evolving from the whole category (kind) wolves (Gelman, 2003).

**Characterizing kinds**

There are three different ways to characterize kinds based upon how a property is connected to the kind and consequently, our conceptual systems distinguish at least three ways of representing the connections between kinds and their properties (Prasada & Dillingham, 2006, 2009; Prasada, Khemlani, Leslie & Glucksberg, 2013). These three ways consist of statistical, causal, and principled connections.

Properties that possess a principled connection to the kind are thought to be an aspect of being that kind of thing. Principled connections include properties that instances of a kind have by virtue of their being the kinds of things that they are, such as having four legs and being a dog. Principled connections (i) license formal explanations that explain the presence of the property in the kind by reference to the kind (e.g., that has four legs because it is a dog), (ii) license normative expectations concerning the presence of the property in the kind (e.g., "That dog, by virtue of being a dog, should have four legs"; we judge there to be something wrong with a dog that does not have four legs), and (iii) license the expectation that the kind will generally possess the property (Prasada and Dillingham, 2006).

Formal explanations allow for a property of an instance of a kind to be accounted for by referencing the kind of thing it is (i.e., "That dog has four legs because it is a dog"). Normative expectations foster the expectation that instances of the kind should have certain properties to which the kind has a principled connection (i.e., "That dog, by virtue of being a dog, should have four legs"). Instances which may lack such a property can be deemed "defective or incomplete" (i.e., A dog with three legs). Lastly, the statistical component of principled connections asserts that principled connections permit the expectation that a property will generally be very common (i.e., "Most dogs are expected to have four legs"). A generic example would include looking at the principled connection between having four legs and being a dog. In other words, having four legs is thought to be an aspect of being a dog (formal explanation), we would likely judge there to be something wrong with a dog that had 3 legs (normative expectation), and the majority of dogs will have four legs (statistical connection). Individuals represent principled connections between the type of thing something is (e.g., a dog) and some of its properties but not others. For example, there is a principled connection between the kind dog and the property of having four legs however, there is no principled connection between the kind dog and the property of wearing a collar. There is, however, a statistical connection present in both examples.

Statistical connections represent properties which are highly statistically correlated with certain kinds. Statistical connections are present in generics such as "barns are red" or "dogs wear collars". Although principled connections license a statistical connection, this is not the case the other way around; statistical connections do not license a principled connection. Statistical connections only involve properties which are prevalent amongst instances of a kind and they do not support formal explanations or normative expectations (Prasada & Dillingham, 2006). Properties that have a principled connection to a kind are represented as aspects of being that kind of thing (Prasada & Dillingham, 2009). Although barns tend to be red, the property being red is not considered an aspect of being a barn nor would there be anything wrong with a barn that is not red.

A causal connection between a kind and a property is distinguished by the shared nature of the members of the kind causing them to be disposed to have the property in question (Prasada, 2010). A few members of the kind possessing the property is not enough to define a causal connection; instead, there must be something about the nature of the kind that causally grounds the presence of the property in the kind. An example of a causal connection would be the kind ticks and the property of carrying Lyme disease. Even though we know that not all ticks carry Lyme disease, their common biological makeup causes ticks to be prone to carrying Lyme disease. Causal connections do not have a formal or normative requirement (Prasada, Khemlani, Leslie & Glucksberg, 2013). As such, the property carrying Lyme disease would not be an aspect of being a tick nor would there be anything wrong with a tick that did not carry Lyme disease. Although individuals generally know that these type of striking property generics (e.g., “Ticks carry Lyme disease”) do not apply to the large majority of instances of the kind (e.g., Not all ticks carry Lyme disease), they still judge these striking property generics to be true (Prasada, Khemlani, Leslie & Glucksberg, 2013), and this is due to the presence of causal connections. Causal connections differ from principled connections in that a high prevalence of the property in the kind is not enough to label the connection as a causal connection. For example, “dogs wear collars” is judged to be true however, it is not because the nature of being a dog causally grounds the presence of a collar.

One important factor to note is that although we have distinguished three different connection types, this does not mean that properties and their kinds are exclusive to one of these connections. There may be given kinds and given properties that fall into all three categories of connections. An example of this would be the kind dog and the property of having four legs. As mentioned previously, there is a statistical connection (high prevalence) between this property and kind; there is also a principled connection between this property and kind; lastly, the nature of being a dog could causally ground the property of having four legs. Each connection type “grounds different kinds of linguistic and nonlinguistic phenomena” and does not result in only one connection type being equivalent to each property and kind combination (Prasada, Khemlani, Leslie & Glucksberg, 2013). Research has also shown that children as young as four years old can differentiate between principled and statistical connections. When asked about properties that have statistical connections and properties that have principled connections to a kind, children and adults had normative expectations, and were more likely to provide a formal explanation, when referring to the properties that have principled connections to the kind (Haward, Wagner, Careya & Prasada, 2018).

**Distinguishing instances versus distinguishing kinds**

When we think about instances of the kind dogs, we do not require two different dogs to have different characteristics. A numerical difference does not imply any qualitative differences. Any specific thing that we can think of will likely have an unlimited number in the category and instances will likely be different from one another. This is not so obvious in the kind paperclips, but it is evident in the kind dogs. Most instances differ from one another numerically and qualitatively (e.g., Spot is a brown dog; Fido is a white dog). However, we treat these qualitative differences as noise. Being brown isn't an aspect of being a dog, but having four legs is. There are properties that have principled connections to the kind (e.g., four legs) and those are the properties that we expect all instances to possess. Likewise, those are the properties that we have formal explanations for, and those are also the properties that the kind is supposed to have. These properties are non-accidentally connected to being a dog. It is important to note that there are other properties, such as those that possess causal or statistical connections to the kind, that are also non-accidentally connected to the kind. However, we do not possess formal explanations or normative expectations for these connection types.

**The problem with minority trait characteristics (sex-linked properties)**

It is widely known that ducks lay eggs and that ducks quack. It is also clear that neither laying eggs, nor quacking, is an accidental property of being a duck. These two properties are lawfully connected to being a duck. Both of these properties (i.e., laying eggs, quacking) are understood to have a principled connection to the kind (duck) in that both are understood to be an aspect of being a duck (Prasada, Khemlani, Leslie & Glucksberg, 2013). Both properties also support formal explanations (i.e., “That lays eggs because it is a duck” and “That quacks because it is a duck”), and both properties support normative expectations (i.e., “Ducks are supposed to lay eggs” and “Ducks are supposed to quack”) (Prasada, Khemlani, Leslie & Glucksberg, 2013). When we compare these two properties, there is an obvious difference between quacking and laying eggs. Quacking is a property that most regular functioning ducks would normally possess however, laying eggs is a property that only mature, female ducks would normally possess.

Minority characteristic (or “sex-linked property”) generics such as “ducks lay eggs” and “lions have manes” are similar to principled generics as 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 tend to be possessed by half or fewer instances of the kind (i.e., only fertile, mature female ducks lay eggs) (Prasada, Khemlani, Leslie & Glucksberg, 2013).

Prasada, Khemlani, Leslie & Glucksberg’s (2013) research on minority characteristic generics found that minority characteristics possess principled connections to the kind. One problem with this way of thinking about minority characteristics possessing principled connections to the kind is that this implies that all ducks that do not lay eggs (i.e., male ducks) must have something wrong with them. One way that previous research suggests we deal with sex-linked property generics is by suggesting that there is a lawful connection to one sex (i.e., the sex linked to the minority characteristic trait/sex-linked property) and not the other (i.e., Lions have manes really means male lions have manes). The problem with this suggestion is that if they appear to be lawfully connected to only instances of one type, they should be included in the concept of that type (female ducks for laying eggs), but not the other type (male ducks for laying eggs). For the same reason, the generic "Female ducks lay eggs" should be licensed, but "Ducks lay eggs" should not.

Lastly, Prasada, Khemlani, Leslie & Glucksberg (2013) concluded that although principled connections underlie minority characteristic generics, the statistical aspect of principled connections only serves to ground the expectation that most instances of the kind will possess the property, not require that most instances of the kind possess the property (Prasada, Khemlani, Leslie & Glucksberg, 2013). The problem with this suggestion is that we expect most male lions to have manes and most female lions not to have manes rather than an expectation that most instances of the kind will possess the property.

When we think about the kind lions, it is clear that male lions have manes and female lions do not have manes. The differences between the male instances and the female instances are not accidental; they are principled. The distinction between male and female is a difference between instances, not a way of dividing lions into sub kinds (e.g., as we do with differed breeds of dogs). An important distinction to make is that sex differences differ from sub kinds due to the fact that we can apply sex differences at multiple levels. We can talk about male and female animals, or male and female dogs, or male and female collies. Distinguishing by sex is a level independent way of distinguishing differences in animal kinds or sub kinds. If we look solely at male lions, they need only differ numerically. Some may be a different shade than others, some may have spots, and some may be smaller. However, these differences are accidental. The same goes for female lions. Now if we compare the differences between male lions and female lions, these differences will be principled in terms of their reproductive capabilities.

Theories of conceptual representation stipulate how instances of kinds are all akin and assume that the ways in which instances vary is not systematic. As such, there is no way of dealing with representing the systematic ways in which instances of animal categories, that also differ in sex, differ from one another. It is evident that the way sex-linked properties of a kind are represented is problematic. The experiments in this study aim to address this problem. The primary goal of this study is to further investigate the types of connections our conceptual systems represent between kinds and properties, while specifically looking at sex-linked properties and how they are represented.

We hypothesize that the principled difference between the two types of instances of sex is due to instances of one type having a principled connection for the presence of a sex-linked property, and the other type having a principled connection for the absence of that property. For example, there is a principled connection between the kind duck and egg-laying such that female ducks are expected to have the property, and male ducks are expected to not have the property. For the kind lion, there is a principled connection between the kind lion and the property of having a mane such that male lions are expected to have the property, and female lions are not expected to have the property. We investigate how the properties are linked to the representation of the kind, and investigate instances of each sex.

This hypothesis is an improvement to current theories of minority characteristic generics because if proven true, the sex that is not linked to the property will not be deemed as having something wrong with it (i.e., “there is something wrong with a female lion that does not have a mane”). This would also establish the expectation that all or most of the sex-linked instances have the property, and all or most of the non-sex-linked instances lack the property (i.e., We expect all or most male lions to have a mane and all or most female lions to not have a mane).

To test our hypothesis, we have conducted four experiments. Experiment 1 investigates whether formal explanations will be supported for both the presence (“That lays eggs because it’s a female duck.”) and the absence (“That does not lay eggs because it’s a male duck.”) of the sex-linked property. Experiment 2 investigates whether normative expectations will be supported for both the presence (“Female ducks are supposed to lay eggs.”) and the absence (“Male ducks are not supposed to lay eggs”) of the sex-linked property. Experiment 3 investigates the normative expectations in a more detailed manner, while also tying the formal explanations and normative expectations together. Lastly, experiment 4 ties together the normative expectations and the statistical expectations licensed by principled connections to sex-linked properties.

**Experiment 1**

Principled connections license formal explanations explaining the presence of the property in the kind by referencing the kind (Prasada and Dillingham, 2006). Experiment 1 investigates the presence of formal explanations in animal kinds that possess sex-linked properties. Experiment 1 follows a similar format to Prasada and Dillingham’s (2006, 2009) studies on formal explanations, where participants were presented with a question and a variety of explanations (including formal explanations). Participants were then asked to rate the naturalness of the response on a 7-point scale. Experiment 1 investigates formal explanations in animal kinds with sex-linked properties. Sex-linked properties have principled connections to the kind even though roughly half of the instances do not possess the property. Given that principled connections support formal explanations (explanations by reference to a category), we hypothesized that formal explanations for the presence of the sex-linked properties would be better when the formal explanation cited the kind (e.g., “because it is a lion”), or the sex linked to the property (e.g., “because it is a male lion”), than when it cited the opposite sex. On the other hand, formal explanations for the absence of the sex-linked property will be better when the sex that is not linked to the property is cited (e.g., "because it is a female lion") than when the kind (e.g., "because it is a lion) or the sex linked to the property (e.g., "because it is a male lion") is cited.

# Method

## Participants

Two hundred individuals, recruited via Amazon Mechanical Turk, participated in this survey which was hosted on Qualtrics. All participants were native English speakers, 18 years or older, and residing in the United States. The survey completion time was approximately 15 minutes. Each participant that completed the survey received $1.50 for participating.

## Materials

A total of 78 questions were presented in the survey. 48 questions were presented regarding formal explanations, equating to 6 questions per animal kind. 8 animal kinds were used throughout this experiment, and the experiments that follow. The eight chosen animal kinds were the ones that we felt possessed well known sex-linked properties, such as manes for lions or laying eggs for ducks. Three of the six questions for each animal kind involved the presence of the sex-linked property, and the other three questions involved the absence of the sex-linked property. Each of the three questions started out identical (e.g., "why does that [pointing to a lion] have a mane?" or "why does that [pointing to a lion] not have a mane?" however, the responses received were varied. The three responses consisted of different explanation types (e.g., "because it is a lion", "because it is a male lion", "because it is a female lion").

This study also included 24 true or false questions (e.g., “Lions have manes”) to assess individuals’ general knowledge about sex-linked properties. We included this second part due to the possibility that not everyone would know these facts, in which case they would just be adding noise to the data and would not bear on the hypothesis. We wanted to ensure the possibility of potentially removing the trials that people did not know about and reanalyzing the data. Given that these results came out statistically significant, we decided not to utilize these true or false questions. This study also included six attention checks (e.g., “Select the number x from the below options.”), which were answered 99% correctly by all participants, showing that they were paying attention to the questions presented.

**Procedure**

Each participant took the same survey, with all questions displayed in random order (see Appendix A for full stimuli and question descriptions). The structure was the same for each question. Participants were shown a question which hypothesized two individuals speaking to one another. The question was structured in the following manner: “Suppose someone asked, ‘why does that [pointing to a lion] have a mane?’ Suppose they received the reply ‘Because it is a lion.’ Please indicate how natural this reply sounds as a response to the question that was asked.” The participant was asked to rate the formal explanation response from a scale of one to seven, one signifying that the response in question was completely unnatural and seven signifying that the response in question was completely natural. The question is used to establish formal explanations between the property and the kind. In theory, the presence of formal explanations would result in a higher rating.

## Results

A 3x2 ANOVA examined the effects of formal explanation type (kind, sex linked to property, sex not linked to property) and property status (present, absent) on the formal explanation judgement ratings. A subject and item analysis, followed by planned comparisons, were used to test whether in the presence of the sex-linked property (e.g., mane), the kind (e.g., lion) and the sex-linked to the property (e.g., male lion) explanation types received higher naturalness ratings than the sex not linked to the property (e.g., female lion) explanation types. This was also used to test whether in the absence of the sex-linked property, the sex not linked to the property (e.g., female lion) received higher naturalness ratings than the kind (e.g., lion) or the sex linked to the property (e.g., male lion). The item analysis allows for us to generalize the results to the whole population of animals and sex-linked properties.

| | Mean | Standard Deviation |
|---|---|---|
| **Property Present in Kind** | 4.86 | 1.46 |
| **Property Present in Sex Linked** | 6.33 | .84 |
| **Property Present in Sex Not Linked** | 3.00 | 1.89 |
| **Property Absent in Kind** | 2.45 | 1.54 |
| **Property Absent in Sex Linked** | 2.67 | 1.91 |
| **Property Absent in Sex Not Linked** | 6.21 | .85 |

*Table 1.* Means and standard deviations of formal explanation ratings for the presence and absence of sex linked properties in kinds.

Table 1 provides the descriptive statistics for each measure in Experiment 1. The property refers to the sex-linked property in each of the explanation types. When explaining the presence of a sex-linked property (i.e., “Why does that (pointing to a duck) lay eggs?”), formal explanations that referenced the kind (i.e., Because it is a duck) (M=4.86), or to the sex linked to the property (Because it is a female duck) (M=6.33), received significantly higher ratings than those that referenced the opposite sex (i.e., Because it is a male duck) (M=3.00). For the absence of the property, formal explanations referencing the opposite sex (i.e., Because it is male duck) received higher ratings (M=6.21) than those referencing the sex linked to the property (i.e., Because it is a female duck) (M=2.67) or the kind (i.e., Because it is a duck) (M=2.45).

For the subject analysis, a two-way (2x3) ANOVA was conducted that examined the effect of presence and explanation type on formal explanation ratings. There was a statistically significant interaction between the effects of presence and explanation type on formal explanation ratings, $F(2, 398) = 524.38$, $p<.001$, $\eta^2 = .73$. The analysis revealed a main effect of presence, $F(1,199) = 362.73$, $p<.001$, $\eta^2 = .65$ and a main effect of explanation, $F(2, 398) = 122.28$, $p<.001$, $\eta^2 = .38$. Next, we ran pairwise t-tests to understand the nature of this interaction.

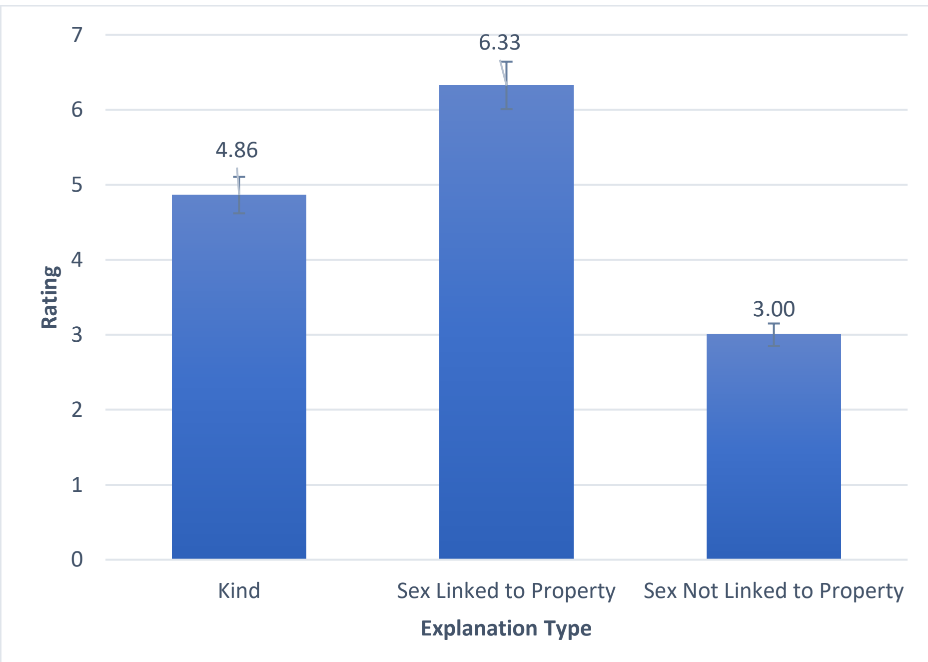


*Figure 1.* Mean formal explanation ratings for the presence of sex-linked properties in kinds.

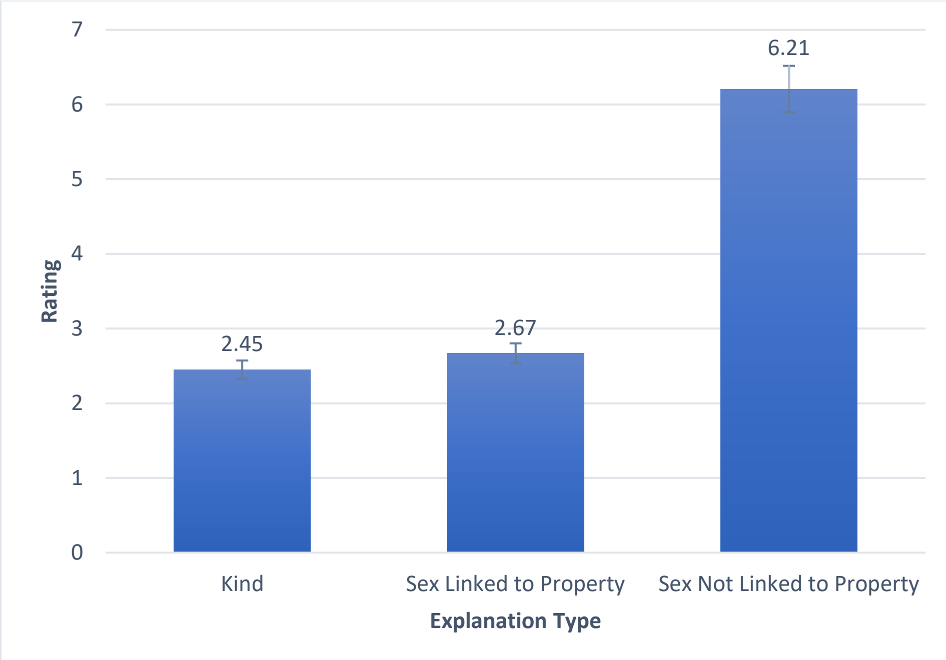


*Figure 2.* Mean formal explanation ratings for the absence of sex-linked properties in kinds.

Pairwise t-tests with Bonferroni correction revealed that, as predicted, for the presence of the property (Figure 1), the kind ($t(199) = 11.72$ , $p < .001$) and the sex-linked to the property ($t(199)= 22.62$ , $p < .001$) were both significantly higher than the sex not linked to the property. Additionally, the sex-linked to the property received significantly higher ratings ($t(199)= 13.55$, $p<.001$) than the kind. For the absence of the property (Figure 2), the sex-not linked to the property was significantly higher ($t(199)= 29.35$, $p< .001$) than the kind and also significantly higher ($t(199)= 24.23$, $p<.001$) than the sex-linked to the property.

For the item analysis, a two-way (2x3) ANOVA was conducted that examined the effect of presence and explanation type on formal explanation ratings. There was a statistically significant interaction between the effects of presence and explanation type on formal explanation ratings, $F (2, 14) =214.38$, $p<.001$, $\eta^2 = .97$. The analysis revealed a main effect of presence, $F (1,7) =98.00$, $p<.001$, $\eta^2 = .93$ and a main effect of explanation, $F (2, 14) =293.98$, $p<.001$, $\eta^2 = .98$.

Pairwise t-tests with Bonferroni correction revealed that, as predicted, for the presence of the property, the kind ($t(7) = 13.79$ , $p < .001$) and the sex-linked to the property ($t(7)= 15.54$ , $p < .001$) were both significantly higher than the sex not linked to the property. Additionally, the sex-linked to the property received significantly higher ratings ($t(7)= 8.36$, $p<.001$) than the kind. For the absence of the property, the sex-not linked to the property was significantly higher ($t(7)= 25.05$, $p< .001$) than the kind and also significantly higher ($t(7)= 14.80$, $p<.001$) than the sex-linked to the property.

## Discussion

Experiment 1 provides evidence that participants found it natural to explain the existence of sex-linked properties by citing the kind and the sex linked to the property. It also provides evidence that participants found it natural to explain the absence of sex-linked properties by citing the sex not linked to the property. In other words, experiment 1 confirms our hypothesis regarding the presence of formal explanations in sex-linked properties. For the presence of the sex-linked property, it is clear that formal explanations are present in the kind and the sex-linked to the property (i.e., lions and male lions for manes). For the absence of the sex-linked property, formal explanations are present in the sex not linked to the property (i.e., female lions for manes).

## Experiment 2

Along with formal explanations, principled connections also license normative expectations regarding the property in the kind (Prasada and Dillingham, 2006). Experiment 2 investigates the normative expectations in animal kinds regarding sex-linked properties. Given that principled connections support normative expectations, we predicted that statements involving a normative expectation for the presence of a sex-linked property (e.g. possessing a mane) would be judged to be true when the statement involves the kind (e.g., "lions are supposed to have manes") or the sex linked to the property (e.g., "male lions are supposed to have manes"), but be judged to be false when the statement involves the opposite sex (e.g., "female lions are supposed to have manes"). We predicted that the kind and sex-linked categories will receive similar ratings. On the other hand, we predicted that statements involving normative expectations for the absence of the sex-linked property will be judged to be true when the sex that is not linked to the property is cited (e.g., "female lions are supposed to not have manes"), but false when the statement involves the kind (e.g., "lions are supposed to not have manes") or the sex linked to the property (e.g., "male lions are supposed to not have manes").

## Method

### Participants

A total of 196 individuals, recruited via Amazon Mechanical Turk, participated in this survey which was hosted on Qualtrics. All participants were native English speakers, 18 years or older, and residing in the United States. The survey completion time was approximately 15 minutes. Each participant that completed the survey received $1.50 for participating.

### Materials

A total of 52 questions were presented in the survey for experiment 2. Out of these, 48 questions were directly related to assessing normative expectations, equating to 6 questions per animal kind. 8 animal kinds were used throughout this experiment (the same animal kinds as experiment 1). The eight chosen animal kinds were the ones that we felt possessed well known sex-linked properties, such as manes for lions or laying eggs for ducks. Three of the six statements for each animal kind involved the presence of the sex-linked property, and the other three statements involved the absence of the sex-linked property. The kind/sub kind (i.e., kind, male kind, female kind) were substituted in each of the three statements for presence and absence. The general structure of each statement followed the following format: "Expectation type (i.e., lions/male lions/female lions are (supposed to/supposed to not) have sex-linked property (i.e., manes). This study also included four attention checks (e.g., "Select the number x from the below options."), which were answered 99% correctly by all participants, showing that they were paying attention to the questions presented.

**Procedure**

Each participant took the same survey, with all questions displayed in random order (see Appendix B for full stimuli and question descriptions). The structure was the same for each question. Participants were shown a statement and then were asked to judge the extent to which the statement struck them as true or false on a 7-point scale. For each question, the participant would see a statement such as "lions are supposed to have manes" or "lions are supposed to not have manes". The participant is then asked to rate the statement on a 7-point scale from negative three to positive three, negative three signifying that the statement in question struck the participant as definitely false and positive three signifying that the statement in question struck the participant as definitely true. The statement and ratings are used to establish normative expectations between the property and the kind. In theory, the presence of normative expectations would result in a higher truth rating.

A 3x2 ANOVA examined the effects of expectation type (kind, sex linked to property, sex not linked to property) and property status (present, absent) on the judgement ratings. This was a within-subject design as each subject provided ratings for items in each condition. A subject and item analysis, followed by planned comparisons, was used to test whether in the presence of the sex-linked property (e.g., mane), the kind (e.g., lion) and the sex-linked to the property (e.g., male lion) expectation types received higher truth ratings than the sex not linked to the property (e.g., female lion) expectation types. This was also used to test whether in the absence of the sex-linked property, the sex not linked to the property (e.g., female lion) received higher truth ratings than the kind (e.g., lion) or the sex linked to the property (e.g., male lion).

## Results

| | Mean | Standard Deviation |
|---|---|---|
| Property Present in Kind | 1.75 | .87 |
| Property Present in Sex Linked | 2.53 | .62 |
| Property Present in Sex Not Linked | -1.91 | 1.03 |
| Property Absent in Kind | -1.98 | .88 |
| Property Absent in Sex Linked | -2.42 | .80 |
| Property Absent in Sex Not Linked | 1.76 | 1.03 |

*Table 2.* Means and standard deviations of normative expectation ratings for the presence and absence of sex linked properties in kinds.

Table 2 provides the descriptive statistics for each measure in Experiment 2. The property refers to the sex-linked property in each of the explanation types. When referring to the presence of the sex-linked property (i.e., mane), the statements with normative expectations that referenced the kind (i.e., lions are supposed to have manes) (M=1.75), or the sex linked to the property (i.e., male lions are supposed to have manes) (M=2.53), received significantly higher ratings than those that referenced the opposite sex (i.e., female lions are supposed to have manes) (M= -1.91). For the absence of the property, normative expectations referencing the opposite sex (i.e., female lions are supposed to not have manes) received higher ratings (M=1.76) than those referencing the sex linked to the property (i.e., male lions are supposed to not have manes) (M= -2.42) or the kind (i.e., lions are supposed to not have manes) (M= -1.98).

For the subject analysis, a two-way (2x3) ANOVA was conducted that examined the effect of presence and explanation type on normative expectation ratings. There was a statistically significant interaction between the effects of presence and explanation type on normative expectation ratings, F (2,390) =1,537.10, p<.001, $\eta^2$ = .89. The analysis revealed a main effect of presence, F (1,195) =771.41, p<.001, $\eta^2$ = .80 and a main effect of explanation, F (2, 390) =17.53, p<.001, $\eta^2$ = .08. Next, we ran pairwise t-tests to understand the nature of this interaction.

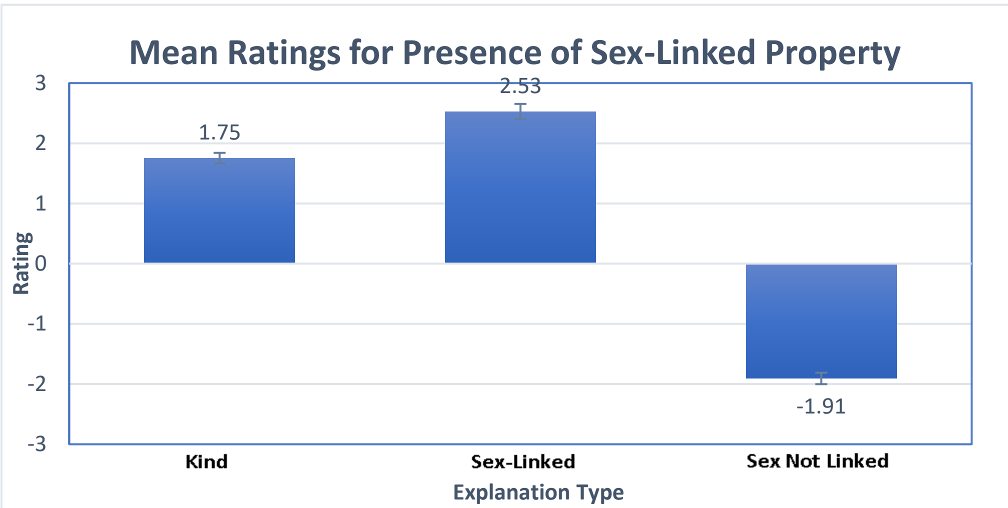


*Figure 3.* Mean normative expectation ratings for the absence of sex-linked properties in kinds.

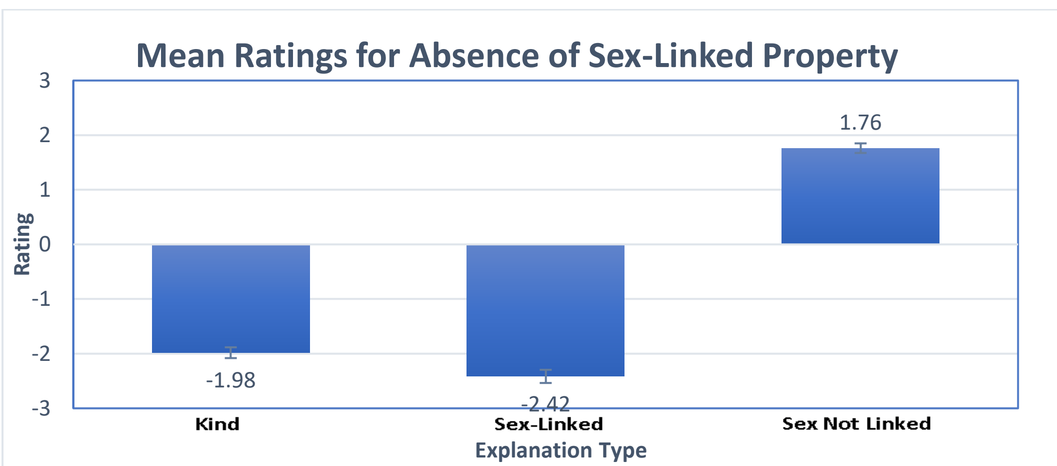


*Figure 4.* Mean normative expectation ratings for the absence of sex-linked properties in kinds.

Pairwise t-tests with Bonferroni correction revealed that, as predicted, for the presence of the property (Figure 3), the kind and the sex-linked to the property were both significantly higher than the sex not linked to the property. For the absence of the property (Figure 4), the sex-not linked to the property was significantly higher than the kind and the sex-linked to the property.

Pairwise t-tests with Bonferroni correction revealed that, as predicted, for the presence of the property (Figure 3), the kind ($t(195) = 39.35$ , $p < .001$) and the sex-linked to the property ($t(195)= 43.05$ , $p < .001$) were both significantly higher than the sex not linked to the property. Additionally, the sex-linked to the property received significantly higher ratings ($t(195)= 12.69$, $p<.001$) than the kind. For the absence of the property (Figure 4), the sex-not linked to the property was significantly higher ($t(195)= 37.07$, $p< .001$) than the kind and also significantly higher ($t(195)= 38.32$, $p<.001$) than the sex-linked to the property.

For the item analysis, a two-way (2x3) ANOVA was conducted that examined the effect of presence and explanation type on normative expectation ratings. There was a statistically significant interaction between the effects of presence and explanation type on normative expectation ratings, $F (2,14) =258.54$, $p<.001$, $\eta^2 = .97$. The analysis revealed a main effect of presence, $F (1,7)$, $=147.42$, $p<.001$, $\eta^2 = .96$ and a main effect of explanation, $F (2, 14) =32.89$, $p<.001$, $\eta^2 = .83$.

Pairwise t-tests with Bonferroni correction revealed that, as predicted, for the presence of the property (Figure 3), the kind ($t(7) = 18.39$ , $p < .001$) and the sex-linked to the property ($t(7)= 17.46$ , $p < .001$) were both significantly higher than the sex not linked to the property. Additionally, the sex-linked to the property received significantly higher ratings ($t(7)= 9.21$, $p<.001$) than the kind. For the absence of the property (Figure 4), the sex-not linked to the property was significantly higher ($t(7)= 15.73$, $p< .001$) than the kind and also significantly higher ($t(7)= 14.60$, $p<.001$) than the sex-linked to the property.

## Discussion

Experiment 2 provides evidence that when considering the presence of a sex-linked property (i.e., a mane), participants judged there to be normative expectations for the kind (i.e., lions are supposed to have manes) and the sex linked to this property (i.e., male lions are supposed to have manes). When considering the absence of a sex-linked property, participants only judged there to be normative expectations for the sex not linked to the property (i.e., female lions are supposed to not have manes). In other words, experiment 2 confirms our hypothesis regarding the normative expectations for sex-linked properties.

## Experiment 3

As mentioned previously, principled connections support both formal explanations and normative expectations. Because of this, instances that lack a property they are supposed to have or have a property they are not supposed to have should be thought of as having something wrong with them and thus to be mutant members of the kind. In addition, the presence or absence of the property in such cases should be explainable by reference to the fact that they are mutant members of the kind.

This experiment compares sex-linked properties in animal kinds to shared properties in animal kinds. If a female lion is missing a tail, it will likely be thought of as a mutant, which inherently provides evidence that there are normative expectations for the presence of a tail in a female lion. However, if a female lion is missing a mane, it will likely not be thought of as a mutant because according to our hypothesis of how sex-linked properties are represented, female lions are expected to not have manes. This experiment further investigates the hypothesis that there is a principled connection between the presence of a sex-linked property and the sex that is linked to this property, as well as a principled connection between the absence of a sex-linked property and the opposite sex. Experiment 3 also allows us to simultaneously investigate formal explanations and normative expectations in sex-linked properties of animal kinds.

We predicted that for the presence of the sex-linked property, formal explanations that reference the mutant kind and the mutant sex linked to the property will receive lower ratings than those that reference the mutant sex not linked to the property. For the absence of the sex-linked property, we predicted that formal explanations that reference the mutant kind and the mutant sex linked to the property will receive higher ratings than the mutant sex not linked to the property. The shared properties will serve as our control condition. For the presence of the shared properties, we predict that all ratings will be low, regardless of explanation type (i.e., mutant kind, mutant sex-linked, mutant non-sex-linked). For the absence of the property, we predict that all of the ratings will be higher than the ratings in the shared present condition. We also predict that in the absence of the shared property, the mutant kind explanation will be rated higher than both the mutant sex-linked and the mutant non-sex-linked explanations.

## Method

### Participants

A total of 177 individuals, recruited via Amazon Mechanical Turk, participated in this survey which was hosted on the Qualtrics platform. All participants were native English speakers, 18 years or older, and residing in the United States. The survey completion time was approximately 25 minutes. Each participant that completed the survey received $1.50 for participating.

### Materials

A total of 100 questions were presented in the survey. Out of these, 96 questions were asked specifically referring to animal kinds, equating to 12 questions per animal kind. 8 animal kinds were used throughout this experiment. The eight chosen animal kinds were the ones that we felt possessed well known sex-linked properties, such as manes for lions or laying eggs for ducks. This experiment included sex-linked properties (i.e., manes for lions) and shared properties (i.e., tails for lions) to compare how participants rate a property that all instances of the kind have with a property that is only linked to one sex. There were 6 questions pertaining to the sex-linked property, and 6 questions pertaining to the shared property. Three of the six questions for each property type involved the presence of the property, and the other three statements involved the absence of the property. The kind/sub kind (i.e., mutant kind, mutant male kind, mutant female kind) were substituted in each of the three responses for presence and absence. This study also included four attention checks (e.g., "Select the number x from the below options."), which were answered 99% correctly by all participants, showing that they were paying attention to the questions presented.

**Procedure**

Each participant took the same survey, with all questions displayed in random order (see Appendix C for full stimuli and question descriptions). This experiment mimics the question structure of experiment 1. Participants were shown a question which hypothesized two individuals speaking to one another. The question was structured in the following manner: "Suppose someone asked, 'why does that [pointing to a lion] have a mane?' Suppose they received the reply 'Because it is a mutant lion.' Please indicate how natural this reply sounds as a response to the question that was asked." The participant was asked to rate the formal explanation response on a 7-point scale, with one signifying that the response in question was completely unnatural and seven signifying that the response in question was completely natural.

This study was structured as a 3x2x2 factorial design with category about which the normative expectation is stated (kind, sex linked to property, sex not linked to property), property status (present, absent), and property type (sex-linked, shared) as the factors. It is a within-subject design; each subject provided ratings for items in each condition.

A subject and item analysis, followed by planned comparisons, were used to test whether in the presence of the sex-linked property (e.g., mane), the kind (e.g., mutant lion) and the sex-linked to the property (e.g., mutant male lion) explanation types received lower naturalness ratings than the sex not linked to the property (e.g., mutant female lion) explanation types. This was also used to test whether in the absence of the sex-linked property, the sex not linked to the property (e.g., mutant female lion) received lower naturalness ratings than the kind (e.g., mutant lion) or the sex linked to the property (e.g., mutant male lion). This analysis was also used to test whether in the presence of the shared property, all three explanations would be equally low, and in the absence of the property, the explanation referring to the mutant kind will be rated higher than either sex.

## Results

| | Mean | Standard Deviation |
|---|---|---|
| Sex-Linked Property Present in Mutant Kind | 2.41 | 1.54 |
| Sex-Linked Property Present in Mutant Sex Linked | 2.13 | 1.44 |
| Sex-Linked Property Present in Mutant Sex Not Linked | 4.16 | 1.72 |
| Sex-Linked Property Absent in Mutant Kind | 4.13 | 1.67 |
| Sex-Linked Property Absent in Mutant Sex Linked | 4.69 | 1.73 |
| Sex-Linked Property Absent in Mutant Sex Not Linked | 2.54 | 1.53 |
| Shared Property Present in Mutant Kind | 2.11 | 1.53 |
| Shared Property Present in Mutant Sex Linked | 1.99 | 1.36 |
| Shared Property Present in Mutant Sex Not Linked | 2.00 | 1.38 |

| | | |
|---|---|---|
| **Shared Property Absent in Mutant Kind** | 5.23 | 1.72 |
| **Shared Property Absent in Mutant Sex Linked** | 4.40 | 1.63 |
| **Shared Property Absent in Mutant Sex Not Linked** | 4.30 | 1.64 |

*Table 3.* Means and standard deviations of formal explanation ratings for the presence and absence of sex linked and shared properties in mutant kinds.

Table 3 provides the descriptive statistics for each measure in Experiment 3. For the subject analysis, a three-way (2x2x3) ANOVA was conducted that examined the effect of presence, property, and explanation type on formal explanation ratings for mutant animal kinds. There was a statistically significant interaction between the three effects on formal explanation ratings, F (2,352) =148.12, p<.001, $\eta^2$ = .46. The analysis revealed a main effect of presence, F (1,176) =267.82, p<.001, $\eta^2$ = .60 and a main effect of explanation, F (2, 352) =15.96, p<.001, $\eta^2$ = .08. There was no main effect of property, F (1,176) = .02, p >.05.

In addition to the above, a 2x3 **subject** ANOVA for the presence of the property with factors property (sex-linked/shared) and explanation (kind, sex-linked, non-sex linked) was conducted. The analysis revealed a main effect of property type, F (1,176) =197.04, p<.001, $\eta^2$ = .53 and a main effect of explanation, F (2, 352) =113.25, p<.001, $\eta^2$ = .39. There is a significant interaction present between property and explanation, F (2,352) =136.74, p<.001, $\eta^2$ = .44.

Lastly, we ran a 2x3 **subject** ANOVA for the absence of the property with factors property (sex-linked/shared) and explanation type (kind, sex-linked, non-sex linked). The analysis revealed a main effect of property type, F (1,176) =101.72, p<.001, $\eta^2$ = .37 and a main effect of explanation, F (2, 352) =145.32, p<.001, $\eta^2$ = .45. There is also a significant interaction present between property type and explanation type, F (2,352) =113.33, p<.001, $\eta^2$ = .39. Next, we ran pairwise t-tests to understand the nature of this interaction.

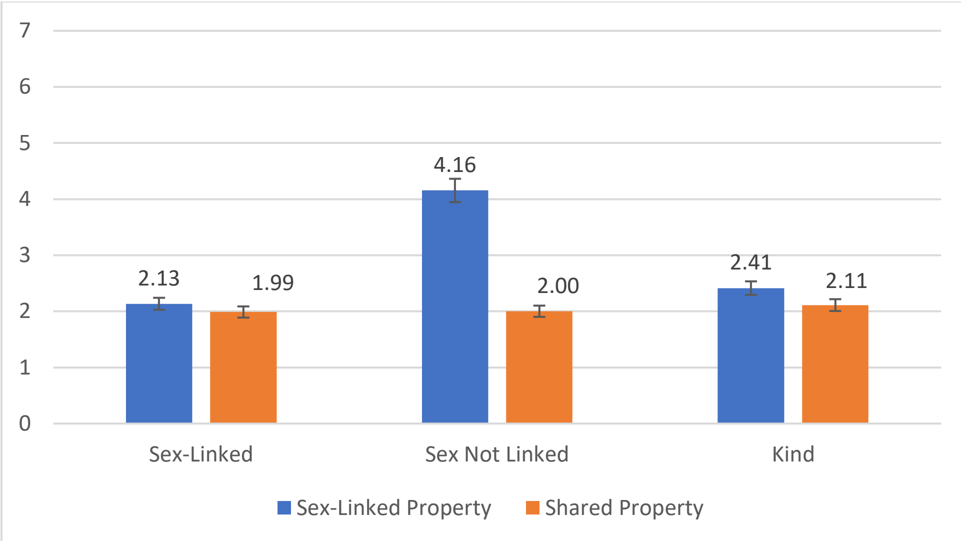


*Figure 5.* Mean ratings for the presence of sex-linked properties and shared properties in mutant kinds.

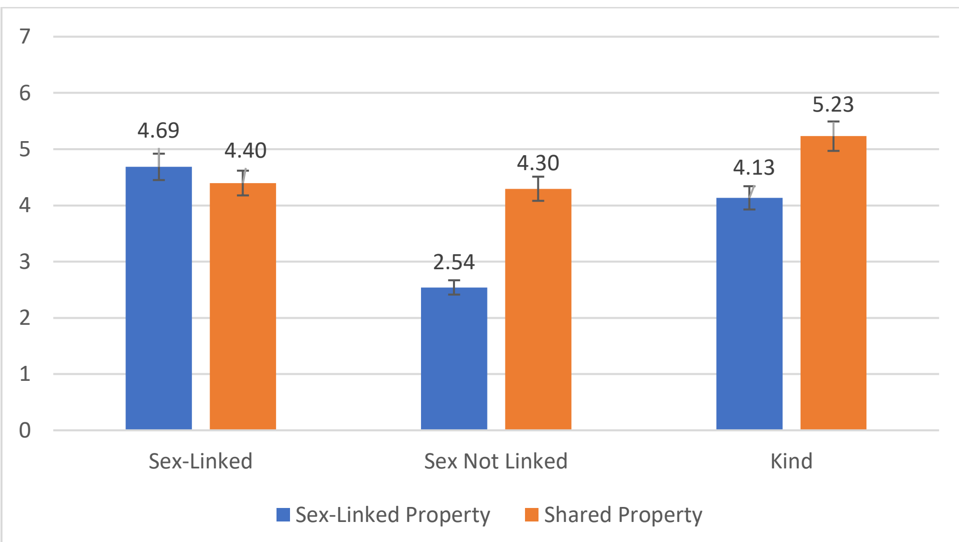


*Figure 6.* Mean ratings for the absence of sex-linked properties and shared properties in mutant kinds.

Pairwise t-tests with Bonferroni correction revealed that, as predicted, when explaining the presence (Figure 5) of a sex-linked property (i.e., “Why does that (pointing to a duck) lay eggs?”), formal explanations that referenced the mutant sex-not linked to the property (i.e., Because it is a mutant male duck) received significantly higher ratings than those referencing the mutant kind (i.e., Because it is a mutant duck) ($t(176)= 11.84$ , $p <.001$) or the mutant sex linked to the property (i.e., Because it is a mutant female duck) ($t(176)= 12.55$, $p <.001$). When explaining the absence of the sex-linked property (Figure 6), formal explanations referencing the mutant kind (i.e., Because it is a mutant duck) ($t(176)= 12.64$ , $p <.001$) or the mutant sex-linked to the property (i.e., Because it is a mutant female duck) ($t(176)= 13.32$ , $p <.001$) received significantly higher ratings than those referencing the mutant sex not linked to the property (i.e., Because it is a mutant male duck). When explaining the presence (Figure 5) of a shared property (i.e., "Why does that (pointing to a duck) have a beak?"), formal explanations that referenced the mutant kind, mutant sex-linked, and mutant sex not linked all received low ratings which were not significantly different. When explaining the absence (Figure 6) of a shared property, formal explanations referencing the mutant kind received significantly higher ratings than formal explanations referencing the mutant sex linked ($t(176)= 9.57$ , $p <.001$) and the mutant sex not linked ($t(176)= 10.27$ , $p <.001$).

For the item analysis, a three-way (2x2x3) ANOVA was conducted that examined the effect of presence, property, and explanation type on formal explanation ratings for mutant animal kinds. There was a statistically significant interaction between the three effects on formal explanation ratings, $F(2,14) =323.25$, $p<.001$, $\eta^2 = .98$. The analysis revealed a main effect of presence, $F(1,7) =2,283.27$, $p<.001$, $\eta^2 = .98$ and a main effect of explanation, $F(2, 14) =45.16$, $p<.001$, $\eta^2 = .87$. There is no main effect of property, $F(2,14) = .039$, $p >.05$.

In addition to the above, a 2x3 **item** ANOVA for the presence of the property with factors property (sex-linked/shared) and explanation (kind, sex-linked, non-sex linked) was conducted. The analysis revealed a main effect of property type, $F(1,7) =383.44$, $p<.00$, $\eta^2 = .98$ and a main effect of explanation, $F(2, 14) =304.60$, $p<.001$, $\eta^2 = .98$. There is a significant interaction present between property type and explanation type, $F(2,14) = 342.49$, $p < .001$, $\eta^2 = .98$.

Lastly, we ran a 2x3 **item** ANOVA for the absence of the property with factors property (sex-linked/shared) and explanation type (kind, sex-linked, non-sex linked). The analysis revealed a main effect of property type, $F(1,7) = 244.51$, $p < .001$, $\eta^2 = .97$ and a main effect of explanation, $F(2, 14) = 396.97$, $p < .001$, $\eta^2 = .98$. There is a significant interaction present between property type and explanation type, $F(2,14) = 186.17$, $p < .001$, $\eta^2 = .96$. Next, we ran pairwise t-tests to understand the nature of this interaction.

Pairwise t-tests with Bonferroni correction revealed that, as predicted, when explaining the presence (Figure 5) of a sex-linked property (i.e., “Why does that (pointing to a duck) lay eggs?”), formal explanations that referenced the mutant sex-not linked to the property (i.e., Because it is a mutant male duck) received significantly higher ratings than those referencing the mutant kind (i.e., Because it is a mutant duck) ($t(7)= 19.13$, $p < .001$) or the mutant sex linked to the property (i.e., Because it is a mutant female duck) ($t(7)= 19.24$, $p < .001$). When explaining the absence of the sex-linked property (Figure 6), formal explanations referencing the mutant kind (i.e., Because it is a mutant duck) ($t(7)= 17.90$, $p < .001$) or the mutant sex-linked to the property (i.e., Because it is a mutant female duck) ($t(7)= 19.85$, $p < .001$) received significantly higher ratings than those referencing the mutant sex not linked to the property (i.e., Because it is a mutant male duck). When explaining the presence (Figure 5) of a shared property (i.e., “Why does that (pointing to a duck) have a beak?”), formal explanations that referenced the mutant kind, mutant sex-linked, and mutant sex not linked all received low ratings, with the mutant kind receiving significantly higher ratings than either the mutant sex-linked ($t(7)= 4.39$, $p < .009$) or mutant sex not linked ($t(7)= 3.30$, $p < .038$). When explaining the absence (Figure 6) of a shared property, formal explanations referencing the mutant kind received significantly higher ratings than formal explanations referencing the mutant sex linked ($t(7)= 12.82$ , $p <.001$) and the mutant sex not linked ($t(7)= 20.78$ , $p <.001$).

## Discussion

Experiment 3 provides evidence that, as predicted, participants found it natural to explain the presence of sex-linked properties (i.e. “Why does that (pointing to a duck) lay eggs?”) by citing the mutant sex not linked to the property (i.e., Because it is a mutant male duck), and not the mutant kind (Because it is a mutant duck) or the mutant sex linked to the property (Because it is a mutant female duck). Participants also found it natural to explain the absence of sex-linked properties (i.e., “Why does that (pointing to a duck) not lay eggs?) by citing the mutant sex linked to the property (Because it is a mutant female duck) and the mutant kind (Because it is a mutant duck). Experiment 3 also provides evidence that, as predicted, participants did not find it natural to explain the presence of a shared property (i.e., “Why does that (pointing to a duck) have a beak?”) by citing the mutant kind (Because it is a mutant duck), the mutant sex linked (Because it is a mutant female duck), or the mutant sex not linked (Because it is a mutant male duck). Lastly, experiment 3 showed that participants found it natural to explain the absence of a shared property (i.e., “Why does that (pointing to a duck) not have a beak?”) by referencing all three mutant kind explanations, however participants found that referencing the mutant kind (Because it is a mutant duck) is significantly more natural than referencing the mutant sex-linked (Because it is a mutant female duck) or the mutant sex not linked (Because it is a mutant male duck).

This experiment directly highlights the problem with generics and sex-linked properties. The results provide evidence that there is a significant difference in the way that we look at the presence and absence of sex-linked properties in comparison to shared properties in animal kinds. As both properties are thought to be principally connected to the kind, the ratings should theoretically be the same for both the sex-linked and the shared properties. This is not the case. Experiment 3 supports the theory that there is a problem with the way sex-linked properties are represented while also providing evidence in support of the solution that we've proposed (i.e., the sex-linked property has a principled connection to the kind such that the presence of the property has a principled connection to the sex that is linked to the property and the absence of the property is principally connected to the opposite sex).

## Experiment 4

Sex-linked properties (e.g., manes for lions) have principled connections to kind representations such that instances of the sex the property is linked to have a principled connection to the property (e.g. there is a principled connection between having a mane and being a male lion). As such, there should be a universal normative expectation for instances of that sex (e.g. All male lions are supposed to have manes), but only a general expectation that all instances *actually* do have the characteristic and thus universal descriptive statements (e.g. All male lions have manes) should be less likely to be judged to be true. Experiment 4 investigates this connection the normative and the statistical aspect of principled connections. We predicted (i) that the normative statements will receive higher ratings than the descriptive statements for the sex-linked category; (ii) a smaller difference in the same direction for the statements about the kind; and (iii) no difference between the normative and descriptive statements for the non-sex-linked category.

## Method

**Participants**

A total of 192 individuals, recruited via Amazon Mechanical Turk, participated in this survey which was hosted on Qualtrics. All participants were native English speakers, 18 years or older, and residing in the United States. The survey completion time was approximately 15 minutes. Each participant that completed the survey received $1.50 for participating.

**Materials**

A total of 52 questions were presented in the survey. Out of these, 48 questions were asked specifically referring to normative or descriptive statements in animal kinds, equating to 6 questions per animal kind. 8 animal kinds were used throughout this experiment (the same animal kinds as experiment 1). The eight chosen animal kinds were the ones that we felt possessed well known sex-linked properties, such as manes for lions or laying eggs for ducks. Out of the six questions for each kind, three showed descriptive statements (e.g., "all lions have manes") and three showed normative statements (e.g., "all lions are supposed to have manes"). Each of the three statements pertained to one kind or sex (i.e., lions, male lions, female lions). The general structure of each statement followed the following format: "All type (i.e., lions/male lions/female lions) have/are supposed to have sex-linked property (i.e., manes). This study also included four attention checks (e.g., "Select the number x from the below options."), which were answered 99% correctly by all participants, showing that they were paying attention to the questions presented.

**Procedure**

Each participant took the same survey, with all questions displayed in random order (see Appendix D for full stimuli and question descriptions). The structure was the same for each question. Participants were shown a statement and then were asked to judge the extent to which the statement struck them as true or false on a 7-point scale. For each question, the participant would see a statement such as “all lions are supposed to have manes” or “all lions have manes”. The participant is then asked to rate the statement on a 7-point scale from negative three to positive three, negative three signifying that the statement in question struck the participant as definitely false and positive three signifying that the statement in question struck the participant as definitely true.

This was a 2x3 within-subject design with type of statement (Normative/Descriptive) and Category (Kind/Sex-linked/Non-sex-linked) as the independent variables. It was a within-subject design as each subject provided ratings for items in each condition.

A 2x3 ANOVA examined the effects of expectation type (kind, sex linked to property, sex not linked to property. A subject and item analysis, followed by planned comparisons, were used to test whether in the presence of the sex-linked property (e.g., mane), the kind (e.g., lion) and the sex-linked to the property (e.g., male lion) expectation types received higher truth ratings than the sex not linked to the property (e.g., female lion) expectation types. This was also used to test whether in the absence of the sex-linked property, the sex not linked to the property (e.g., female lion) received higher truth ratings than the kind (e.g., lion) or the sex linked to the property (e.g., male lion). The item analysis allows for us to generalize the results to the whole population of animals and sex-linked properties.

## Results

| | Mean | Standard Deviation |
|---|---|---|
| Normative Statements for Kind | -1.60 | 1.10 |
| Normative Statements For Sex Linked | 2.24 | .77 |

| | | |
|---|---|---|
| **Normative Statement For Sex Not Linked** | -2.08 | .98 |
| **Descriptive Statements for Kind** | -1.72 | 1.09 |
| **Descriptive Statements For Sex Linked** | 1.85 | 1.01 |
| **Descriptive Statement For Sex Not Linked** | -2.11 | .90 |

*Table 4.* Means and standard deviations of truth ratings for normative and descriptive statements regarding sex linked properties in kinds.

Table 4 provides the descriptive statistics for Experiment 4. For the subject analysis, a two-way (2x3) ANOVA was conducted that examined the effect of statement type and explanation on participants ratings. There was a statistically significant interaction between the effects of statement type and explanation on participant ratings, $F (2,382) = 22.70$, $p < .001$, $\eta^2 = .11$. The analysis revealed a main effect of statement type, $F (1,191) = 36.5$, $p < .001$, $\eta^2 = .16$ and a main effect of explanation, $F (2, 382) = 1342.58$, $p < .001$, $\eta^2 = .88$. Pairwise t-tests with Bonferroni correction revealed that, as predicted, the normative ratings were significantly higher than the descriptive ratings for the kind ($t(191) = 3.23$, $p = .001$) and for the sex-linked explanation types ($t(191) = 6.86$ , $p < .001$). Alternatively, there was no significant difference between the two types of statements for the non-sex-linked explanation type.

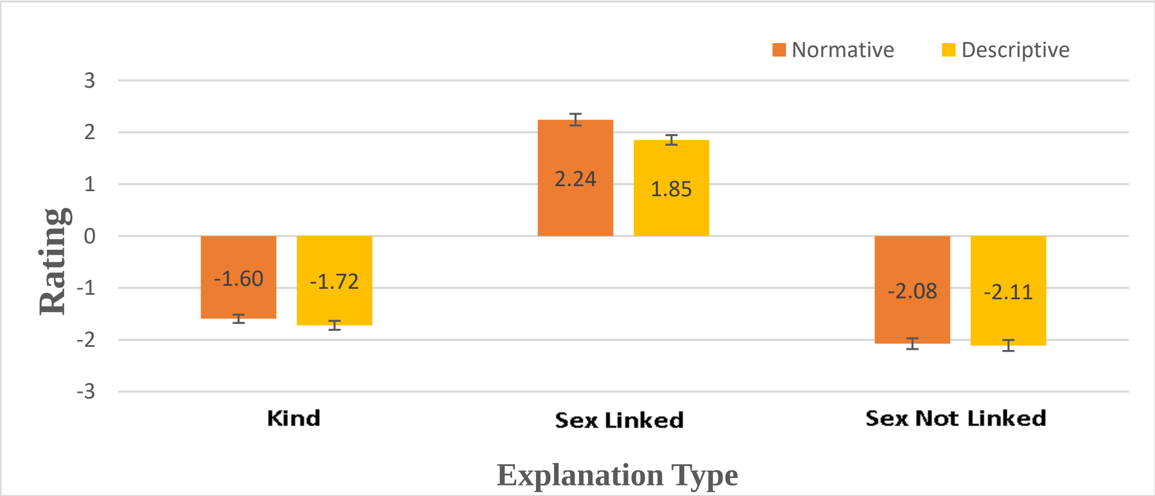


*Figure 4.* Mean normative and descriptive statement ratings for each explanation type.

Figure 7 shows the mean ratings for the normative and descriptive statements by explanation type. For the item analysis, a two-way (2x3) ANOVA was conducted that examined the effect of statement type and explanation on participants ratings. There was a statistically significant interaction between the effects of statement type and explanation on participant ratings, $F(2,14) = 21.00$, $p < .001$, $\eta^2 = .75$. The analysis revealed a main effect of statement Type, $F(1,7) = 132.69$, $p < .001$, $\eta^2 = .95$ and a main effect of explanation, $F(2, 14) = 336.55$, $p < .001$, $\eta^2 = .98$. Pairwise t-tests with Bonferroni correction revealed that, as predicted, the normative ratings were significantly higher than the descriptive ratings for the kind ($t(7) = 4.67$, $p = .002$) and for the sex-linked explanation types ($t(7) = 7.52$, $p < .001$). Alternatively, there was no significant difference between the two types of statements for the non-sex-linked explanation type.

## Discussion

As predicted, there was a significant interaction present between type of statement and explanation type. For statements involving the kind, both statement types received low ratings however, the ratings for normative statements ($M = -1.60$) were significantly higher than the descriptive statements ($M = -1.72$). Participants also endorsed normative statements that all instances of the sex linked to a property are supposed to have the property ($M = 2.24$), to a greater extent than descriptive statements that they all have the property ($M = 1.85$). This follows our prediction that universal descriptive statements (i.e., All male lions have manes) should be less likely to be judged to be true than universal normative statements (i.e., All male lions should have manes). Lastly, as expected, there was no significant difference between statement types for the statements involving the non-sex linked instances. This experiment provides evidence in support of our general hypothesis. This provides evidence that normative and descriptive (statistical) statements are intrinsically connected in principled connections.

## General Discussion

Experiment 1 confirms that formal explanations can be given for the presence of sex-linked properties by reference to the kind (i.e., “Why does that (pointing to a lion) have a mane?” “Because it is a lion”), and the sex linked to the property (i.e., “Why does that (pointing to a lion) have a mane?” “Because it is a male lion”), and the absence of sex-linked properties can be explained by reference to the opposite sex/sex not linked to the properties (“Why does that (pointing to a lion) not have a mane?” “Because it is a female lion”).

Experiment 2 confirms the existence of normative expectations regarding the presence of sex-linked properties for the kind (i.e., “Lions are supposed to have manes”), and the sex linked to the property (i.e., “Male lions are supposed to have manes”), and normative expectations for the absence of the sex-linked properties in the opposite sex/sex not linked to the properties (i.e., “Female lions are supposed to not have manes”).

Experiment 3 tied the formal explanations and the normative expectations together, while revealing the significant differences between sex-linked properties and shared properties. Experiment 4 revealed that, unlike what previous research regarding minority trait characteristics has stated, we have statistical expectations regarding sex-linked properties.  Furthermore, it showed that normative and descriptive (statistical) expectations are intrinsically connected in principled connections.

The experiments listed above confirm that animate kinds formally distinguish instances of two types (male/female) such that instances of the two types differ in a principled manner. These experiments also provide clear evidence in support of our hypothesis that the principled difference between the two types of instances is due to instances of one type having a principled connection for the presence of a sex-linked property, and the other type having a principled connection for the absence of that property. Generics like "Ducks lay eggs" are licensed because we represent a lawful connection between the kind and the property, not just between one sex and the property.

***How do present results bear on previous ideas about sex-linked properties (minority trait characteristics)?***

Previous research has argued that minority trait characteristic generics do not need to possess the statistical component in order to be considered principally connected to the kind (Prasada, Khemlani, Leslie & Glucksberg, 2013). This explanation is used to accommodate for the sex that does not possess the minority trait characteristics. Experiment 4 provides evidence that there is in fact a strong statistical connection between the sex-linked property and the kind. This suggests that we do not lack statistical expectations in principled connections.

Prior research on minority trait characteristics asserts that principled connections involve normative expectations (Prasada, Khemlani, Leslie & Glucksberg, 2013) however, it does not account for the opposite sex (i.e., we do not consider female lions to be defective). Experiment 2 provides evidence that there are normative expectations for the presence of the property in one sex, and normative expectations for the absence in the property in the opposite sex. This is an improvement to current theories as it does not require us to consider the sex which is not linked to the property and thus lacks the property as being defective.

Some prior research has also argued that “lions have manes” really refers to male lions, or all mature male lions, having manes (Declerck, 1991). The limitation present in this research is that if this is the case, it says that we don’t have any expectations for female lions. However, all of the present experiments provide evidence that we do indeed have expectations for female lions, and generally have expectations for the sex-linked instances of the kind and the non-sex-linked instances of the kind.

Lastly, previous work has shown that conceptual representations include descriptive characteristics (i.e., what a kind has) (e.g. Medin, 1989; Murphy, 2002) and prescriptive characteristics (i.e., what a kind should have) (e.g. Prasada & Dillingham, 2006, 2009; Prasada et al., 2013; Haward et al., 2018). The research in the present studies provides evidence that in some cases, concepts also specify proscriptive characteristics (i.e., what a kind should not have). The results of these experiments also enhance our knowledge of how we represent concepts of animals and sex differences found in members of animal categories.

***Implications of this work for our understanding of generic and principled connections***

Previously, evidence for each of the three aspects (i.e., formal, normative, statistical) of principled connections was provided separately. Experiment 3 provides evidence that formal explanations and normative expectations are intrinsically connected. Experiment 4 provides evidence that normative expectations and statistical expectations are also intrinsically connected. This indicates that principled connections always carry explanatory, normative, and statistical connections. The evidence also shows that principled connections involve a connection to the kind, and not just to one type of instance of the kind (e.g., male/female). For example, “lions have manes” should be interpreted as a statement about the kind lions and not just a statement about male lions. The present experiments provide evidence that there is a lawful connection between lions and manes. Female lions are lawfully connected to the absence of manes and male lions are lawfully connected to the presence of manes. This explains why generics involving the kind and a sex-linked property are licensed (e.g., Lions have manes), as well as why generics involving both the sex linked to the property (e.g., Male lions have manes) and the sex not linked to the property are also licensed (e.g., Female lions do not have manes).

### *Considerations for future research*

An important consideration for future research would be to investigate how children learn about sex-linked properties. This research could also investigate how children know that sex-linked properties involve principled connections, and at what age do children tend to possess this knowledge. A study investigating how children understand and represent generics involving gender categories found that children as young as 4.5 years old derive inferences regarding unmentioned categories in generic claims (Moty and Rhodes, 2021). The study provided evidence that when children are presented with a statement about one group, they will naturally assume this statement is not true for the other group. Perhaps this could be the case with lions and manes. Evidence also shows that the tendency for children to draw inferences about the neglected categories strengthens with age (Moty and Rhodes, 2021). It may be important to understand how this result ties in with regard to principled connections, and whether they involve the same process. Principled connections were not present in any of the items provided to the children however, it would be interesting to replicate the experiment with sex-linked properties specifically.

An additional consideration for future research may be to conduct a study similar to this one but pertaining to sex-linked properties in humans. More specifically, investigating how the ratings for formal explanations, normative expectations, and statistical components may be different when referring to sex-linked properties in women and men. It may be interesting to compare those results with the results for animal kinds since animals do not have concepts of gender in the same way that humans do. It may also be interesting to incorporate the survey across several generations of people in order to see whether ratings differ significantly based upon age. Lastly, some additional questions for future research include: Could there be properties that do not involve principled connections but could always be found in one sex and not the other? How can our knowledge of generics and kind concepts be used to explain the differences between queen bees and worker bees in the generic “Bees make honey”? Is that distinction represented in the same way as sex differences are represented?

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# Appendix A

## Appendix A: Stimuli and script for Experiment 1

**Table A1**

**Kinds, Sex-Linked Properties, and Sexes Linked/Not Linked to Property for Experiment 1, 2, and 4**

| Sex-Linked Property | Kind | Sex-Linked to Property | Sex Not Linked to Property |
|---|---|---|---|
| Mane | Lion | Male Lion | Female Lion |
| Laying Eggs | Duck | Female Duck | Male Duck |
| Udders | Cow | Female Cow | Male Cow |
| Colorful Tail Feathers | Peacock | Male Peacock | Female Peacock |
| Pouch | Kangaroo | Female Kangaroo | Male Kangaroo |
| Producing Milk | Sheep | Female Sheep | Male Sheep |
| Antlers | Deer | Male Deer | Female Deer |
| Horns | Goat | Male Goat | Female Goat |

### A.1. Question Template for Experiment 1

Suppose someone asked, "Why does that [pointing to kind] (have/not have) a sex-linked property?"

Suppose they received the reply, "Because it is a (kind/sex-linked to property/sex not linked to property)."

Please indicate how natural this reply sounds as a response to the question that was asked.

**Example: LION**

***For Presence in Kind:*** Suppose someone asked, "Why does that [pointing to a lion] have a mane?"

Suppose they received the reply, "Because it is a lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Presence in Sex-Linked:*** Suppose someone asked, "Why does that [pointing to a lion] have a mane?"

Suppose they received the reply, "Because it is a male lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Presence in Non-Sex-Linked:*** Suppose someone asked, "Why does that [pointing to a lion] have a mane?"

Suppose they received the reply, "Because it is a female lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Kind:*** Suppose someone asked, "Why does that [pointing to a lion] not have a mane?"

Suppose they received the reply, "Because it is a lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Sex-Linked:*** Suppose someone asked, "Why does that [pointing to a lion] not have a mane?"

Suppose they received the reply, "Because it is a male lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Non-Sex-Linked:*** Suppose someone asked, "Why does that [pointing to a lion] not have a mane?"

Suppose they received the reply, "Because it is a female lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

# Appendix B

## *Appendix B: Script for Experiment 2*

**Refer to Table A1 for stimuli**

### B.1. Question Template for Experiment 2

"(Kind/Sex-Linked/Sex Not Linked) are supposed to (have/not have) (sex-linked property)."
Please provide a judgement as to whether the statement strikes you as true or not.

**Example: LION**
***For Presence in Kind***: "Lions are supposed to have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Presence in Sex-Linked:*** "Male lions are supposed to have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Presence in Non-Sex Linked:*** "Female lions are supposed to have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Absence in Kind:*** "Lions are supposed to not have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Absence in Sex-Linked:*** "Male lions are supposed to not have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Absence in Non-Sex Linked***: "Female lions are supposed to not have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

# Appendix C

***Appendix C: Stimuli and Script for Experiment 2***

**Table C1**

**Kinds, Sex-Linked and Shared Properties, and Sexes Linked/Not Linked to Property for Experiment 3**

| Sex-Linked Property | Shared Property | Kind | Sex-Linked to Property | Sex Not Linked to Property |
|---|---|---|---|---|
| Mane | Tail | Lion | Male Lion | Female Lion |
| Laying Eggs | Webbed Feet | Duck | Female Duck | Male Duck |
| Udders | Ears | Cow | Female Cow | Male Cow |
| Colorful Tail Feathers | Beak | Peacock | Male Peacock | Female Peacock |
| Pouch | Hop | Kangaroo | Female Kangaroo | Male Kangaroo |
| Producing Milk | Wool | Sheep | Female Sheep | Male Sheep |
| Antlers | Hooves | Deer | Male Deer | Female Deer |
| Horns | Four Legs | Goat | Male Goat | Female Goat |

**C.1. Question Template for Experiment 3**

Suppose someone asked, "Why does that [pointing to kind] (have/not have) a (sex-linked property/shared property)?"

Suppose they received the reply, "Because it is a mutant (kind/sex-linked to property/sex not linked to property)."

Please indicate how natural this reply sounds as a response to the question that was asked.

**Example: LION**

***For Sex-Linked Property:***

***For Presence in Kind:*** Suppose someone asked, "Why does that [pointing to a lion] have a mane?"

Suppose they received the reply, "Because it is a mutant lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Presence in Sex-Linked:*** Suppose someone asked, "Why does that [pointing to a lion] have a mane?"

Suppose they received the reply, "Because it is a mutant male lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Presence in Non-Sex-Linked:*** Suppose someone asked, "Why does that [pointing to a lion] have a mane?"

Suppose they received the reply, "Because it is a mutant female lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Kind:*** Suppose someone asked, "Why does that [pointing to a lion] not have a mane?"

Suppose they received the reply, "Because it is a mutant lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Sex-Linked:*** Suppose someone asked, "Why does that [pointing to a lion] not have a mane?"

Suppose they received the reply, "Because it is a mutant male lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Non-Sex-Linked:*** Suppose someone asked, "Why does that [pointing to a lion] not have a mane?"

Suppose they received the reply, "Because it is a mutant female lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Shared Property:***

***For Presence in Kind:*** Suppose someone asked, "Why does that [pointing to a lion] have a tail?"

Suppose they received the reply, "Because it is a mutant lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Presence in Sex Linked to Sex-Linked Property:*** Suppose someone asked, "Why does that [pointing to a lion] have a tail?"

Suppose they received the reply, "Because it is a mutant male lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Presence in Sex Not Linked to Sex-Linked Property:*** Suppose someone asked, "Why does that [pointing to a lion] have a tail?"

Suppose they received the reply, "Because it is a mutant female lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Kind:*** Suppose someone asked, "Why does that [pointing to a lion] not have a tail?"

Suppose they received the reply, "Because it is a mutant lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Sex Linked to Sex-Linked Property:*** Suppose someone asked, "Why does that [pointing to a lion] not have a tail?"

Suppose they received the reply, "Because it is a mutant male lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

***For Absence in Sex Not Linked to Sex-Linked Property:*** Suppose someone asked, "Why does that [pointing to a lion] not have a tail?"

Suppose they received the reply, "Because it is a mutant female lion."

Please indicate how natural this reply sounds as a response to the question that was asked.

# Appendix D

***Appendix D: Stimuli and Script for Experiment 4***

**Refer to Table A1 for stimuli**

**D.1. Question Template for Experiment 4**

"All (Kind/Sex-Linked/Sex Not Linked) (have/are supposed to have) (sex-linked property)."
Please provide a judgement as to whether the statement strikes you as true or not.

**Example: LION**
***For Normative Kind****:* "All lions are supposed to have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Normative Sex-Linked:*** "All male lions are supposed to have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Normative Non-Sex Linked:*** "All female lions are supposed to have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Descriptive Kind****:* "All lions have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Descriptive Sex-Linked:*** "All male lions have manes."
Please provide a judgement as to whether the statement strikes you as true or not.

***For Descriptive Non-Sex Linked:*** "All female lions have manes."
Please provide a judgement as to whether the statement strikes you as true or not.