The role of prior knowledge and expertise on choice of referring expression

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Abstract

Referential success depends on choice of referring expression. The choice of referring expression will depend on contextual factors as well as factors related to speaker and addressee knowledge. A shared-learning paradigm was used in which partners learned names of objects together and separately before a referential task. Items differed on commonality, with some independently rated as more common and some as more rare. Speakers were less likely to use names versus other forms when items were rare than common ($p<0.001$) and less likely to use names when items were new than learned together ($p<0.001$). Asymmetry effects showed that speakers were more likely to use a name when the addressee was deemed more knowledgeable in post-test ratings ($p<0.01$). Together, we take this to show speakers choose to use a name versus a description based on the *likelihood* that their interlocutor will know the name. Factors affecting the likelihood include prior knowledge of what a typical addressee will know and shared experience, which includes inferring an interlocutor's expertise, as dynamically updated during a dialog.

Keywords: interactive conversation; referring expressions; common ground; expertise, belief updating

Introduction

In interactive conversation, the likelihood of a speaker's referential success depends on choice of referring expression. A speaker's choice to refer to a picture as, say, a "dog" versus a "Bernese Mountain dog" or "the large black dog with a white chest and tan marking", depends on factors relevant to the context, the speaker, and the addressee. If, for example, the referential domain includes multiple dogs, a more specific label will be needed to pick out a unique object; whereas a domain with a single dog and several cats is likely to elicit the basic label "dog". A speaker's knowledge, or lack of knowledge, of dog breeds will restrict the name alternatives the speaker will have readily available, as will the speaker's assessment of the addressee's knowledge—e.g., if the speaker is aware that the addressee does not know a breed of dog, the speaker may choose to describe the dog rather than use the name of the breed.

Speakers readily distinguish between differences in knowledge when they learn novel names for novel objects with a partner (Wu & Keysar, 2007; Heller et al. 2012; Gorman et al., 2013). In this shared-learning paradigm, participants learn some novel names together (shared names) and then one participant, who is subsequently the director in a referential task, learns additional names alone (privileged names). This creates a situation of knowledge asymmetry that the speaker may use to inform choice of referring form in the referential task. Speakers indeed track shared experience when the objects are novel, i.e., when they have not seen the objects prior to the experiment. They use more names than descriptions for those objects that have been learned together. (Wu & Keysar, 2007); and rarely use the name-alone form for privileged names (Heller et al. 2012; Gorman et al., 2013).

In related work, Gegg-Harrison (2016, also see Gegg-Harrison & Tanenhaus, 2016) embedded name learning in the context of a toy world. In a role-playing game, certain levels were always encountered before others. The participant's choices made regions of the world and the information contained there inaccessible. Therefore, a participant who displayed knowledge of a particular name would implicate that she would know some names but not others. The participant then interacted with a game expert in several tasks that involved characters from the toy world. Interactions with the expert showed that the participant modified her name use and assessment of what the speaker knew based on the expert's use of names.

In most conversations, especially with a relatively unfamiliar addressee, a speaker will not have direct, shared experience. If we assume that speakers choose to use a name because it is the least resource demanding, shortest, and richest referring expression, then a rational speaker would take into account the likelihood that the addressee would know the name. That likelihood would be based on both the likelihood that any addressee would know that name (baseline likelihood) and evidence specific to that addressee, much of which is gleaned from the ongoing conversation.

To lay the groundwork for explicitly evaluating the likelihood hypothesis, we modify the shared-learning paradigm by using pictures of real entities that vary in baseline likelihood and by having the learning be interactive, which allows the director to have assessed the expertise of the matcher. We hypothesize that name use will be affected

by both baseline likelihood and shared experience, including inferred level of expertise, with larger effects of shared learning for less commonly known (rare) names and lower name usage for matchers who are judged to have lower expertise, especially for rare names, even when they have been learned together. If we can establish that the paradigm is sensitive to expertise, then this allows for more targeted questions about the factors, including prosody and choice of lexical expressions, that interlocutors use to signal and infer which names are likely to be know to each other.

Using novel names and novel objects is well-suited for asking basic questions about whether speakers can form item-specific memories of shared experience that can be used as a basis for common ground. However, limitation of using novel objects and novel names is that it abstracts away from two important characteristics that influence choice of referential forms. The first is the speakers' prior beliefs about how likely any interlocutor is to know a name. For example, any speaker of English can assume that her interlocutor will know the general category of dogs and its base-level name. The second is that it doesn't capture the dynamic aspect of interactive conversation. A speaker is unlikely to know the full extent of her addressee's knowledge about a topic prior to an interaction. Rather she may draw inferences based on what her interlocutor reveals during the interaction. For example, if a speaker learns that his interlocutor is a gourmet cook, he can assume that she will know the names for even relatively rare kitchen utensils. This assumption is possible even without direct evidence of knowledge of particular names by attributing to that interlocutor knowledge that is likely known by most gourmet cooks.

The present study extends the shared-learning paradigm in two important ways. First, we use real objects drawn from categories, in particular dog breeds and kitchen utensils, in which there are commonly known names (e.g., "tongs") and less common (rare) names (e.g., "mandoline"). We normed items as common or rare to *the average person* but chose categories that might differ in expertise given broad designations of communities (i.e., cooks and dog lovers). Second we modify the shared-learning paradigm to create conditions where participants have the opportunity to assess each other's expertise in a domain. This will allow one to tease apart whether assessment of addressee knowledge is acquired throughout the interaction by cues separately from the shared experience of learning names together.

Specifically, we ask whether the evidence that shared learning of novel objects informs referential choice can be interpreted as a part of a larger likelihood computation that also incorporates common knowledge, shared experience and inferred expertise. It could be the case that shared experience effects seen with novel objects can be attributed to the triggering of episodic traces, such that when a speaker chooses to refer to an object, the memory of having learned it with a specific addressee is activated, which in turn informs referential choice (Horton & Gerrig, 2005). The low-level trace is enough to explain the shared learning effects. A speaker, however, may come into the experiment with a prior belief about a partner's likely knowledge that gets updated as more evidence is presented. Thus, when the partners learn novel names together, the speaker updates the belief that the addressee knows the name, having learned it together. In the paradigm with novel objects, this belief is likely binary: they either learn it together in the experimental context or not. The present study, however, in its incorporation of real-world objects, creates a situation in which interlocutors not only may have different prior beliefs about the addressee's knowledge at the beginning of the experiment but may also dynamically update those beliefs throughout the interaction. The assessment of a partner's knowledge via shared experience as well as its updating, of course, also involves memory processes. However, it is not clear how memory traces with a specific partner could account for how beliefs of the overall commonality of an object interact with that shared experience. Furthermore, as the interaction unfolds, it is not clear whether further updating of this belief occurs given evidence from the interaction. An episodic trace would not predict its effect on referential choice for new items, for example. If episodic traces are driving the effects of shared learning, then speakers will be equally sensitive to the shared experience of learning names in the context of the experiment. However, if commonality and inferred expertise combine with shared experience to determine the overall likelihood of an addressee knowing a name, then one cannot *only* appeal to episodic-based explanations.

The present study concerns itself with the following questions: 1) Does the commonality of an object impact the effect of shared learning with a partner? 2) Do interlocutors dynamically update their beliefs about their partner's expertise in a subject? If so, does this expertise interact with commonality and shared learning to inform the speaker's choice of referring form?

We predict that if items are more likely to be known prior to the experiment, shared experience in the experiment is less likely to affect choice of referring expression. Conversely, if rare items are similar to novel items in past studies (i.e., associated with low or no prior knowledge), then the shared experience effects are likely to be strongest in this group. Furthermore, if expertise is inferred throughout the interaction, then the effects of commonality and/or shared experience, if any, should differ according to whether the addressee is deemed to be knowledgeable in the domain or not. Finally, although the effects of shared experience will be smaller for common names, we should still see some effects; this would suggest that shared experience enters into likelihood calculations, even for commonly known names.

Methods

The experiment consisted of three parts: a learning phase, in which the participants learned the name of items in two categories--dog breeds & kitchen utensils; a test phase, in which one participant directs the other to pick out a target item in a referential task; and a post-test, in which participants rate their partner's, and their own, knowledge of

the items as well as identify the context of learning. See Figure 1 for an illustration of these three parts.

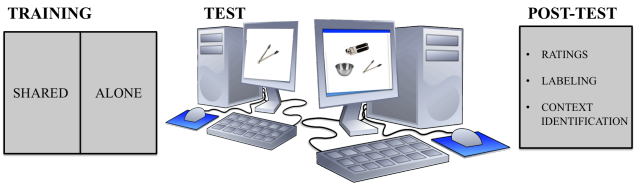

Figure 1: Experimental procedure consisting of the Learning phase (i.e., Training), the Test phase, and Post-test phase.

Norming

The items used in this experiment were normed and rated as either common or rare from two categories on which people often differ in expertise (dog breeds and kitchen utensils). See Figure 2 for sample stimuli of kitchen utensils. The norming procedure consisted of a presentation of 8 images (4 dog breeds, 4 kitchen items, with 2 common and 2 rare of each category). Each image was presented one at a time and participants were tasked to 1) label the image, 2) provide a confidence rating for that label, and 3) indicate how likely it is that the average person would know the label.

There were 80 unique images normed, separated into 10 lists of 8 items. 600 total participants were tested (roughly 60 people per list) with an average of 58.8 data points per item, due to some blank responses for single items.

Of the 80 unique items normed, we chose 36 experimental items: 12 for shared learning; 12 for director-alone learning; and 12 new items to be tested but not trained on. Half of all items (n=18) were dogs and the other half (n=18) were kitchen items. Within each of these categories, half (n=9) were rare, and half (n=9) were common.

We chose the items by first sorting by largest sample. For common items, we then took the items with the highest average rating (i.e., the knowledge rating for the "average person") with the highest accuracy of labeling (above 70% accuracy). For rare items, we took the items with the lowest average rating (i.e., the knowledge rating for the "average person") with the highest accuracy (above 10% accuracy). A minimum of 10% accuracy was implemented in order to remove items that had a name that was incorrect but confidently rated (e.g., "Greyhound" was a highly repeated label for an Azawakh, resulting in 0% accuracy).

Rare Kitchen **Mandoline**	Common Kitchen **Tongs**
	

Figure 2: Sample stimuli of rare and common kitchen utensils.

The Learning Phase

The learning phase allowed participants to observe each other's expertise. We manipulated whether names were shared or privileged by dividing the phase into shared learning among the two partners and director-alone learning. This allowed us to observe how a speaker combines shared experience with general likelihood of knowing a name and modulates choice of referring expression by perceived differences in expertise.

At the beginning of the learning phase, participants sit together at a table with the experimenter standing in front of them. Based on seating arrangement, each participant is assigned as either the Director or the Matcher.

For the shared-learning portion of the learning phase, the experimenter explains to the participants that they will be learning names of items together and that the images will be of different dogs and different kitchen items which they may or may not be familiar with. The experimenter then presents a flashcard with an individual image one at a time. After presenting the image, participants discuss with one another whether they know the name of the image. If they know it, they say the name aloud. After given some time to guess, the experimenter states the correct name of the item. This procedure is done for 12 items, presented in three blocks of four items. After each block, the items are repeated once more before moving to the next block. After all three blocks, the participants go through the whole stack.

For the second half of the learning phase (Director-alone learning), the Matcher sits at a computer in the same room and is instructed to wear headphones playing instrumental music while engaging in a game of Solitaire. During this time, the experimenter presents the Director with 12 additional images. The procedure is as above, with three blocks of four items. Thus, together with the shared learning portion, a total of 24 items were presented in the learning phase, holding out the last 12 items for the test phase.

Both portions of the learning phase (shared and Director-alone) are recorded and transcribed.

The Test Phase

Following the learning phase, the participants began the test phase, which was a referential task in which the Director verbally leads the Matcher to pick out a target item from an array. The test phase created a situation for the Director to refer to the items of varying commonality and ground status that were introduced in the learning phase in a controlled referential task.

Both Matcher and Director sat at their own computer facing one another. The Director was shown one image on the screen, which could be an image that was learned together with the Matcher, learned alone, or never presented during the learning phase. The Matcher, on the other hand, was presented with three images. All three images were of the same category (i.e, all dogs or all kitchen items), and they are of same commonality (i.e., all rare or all common). The difference among the images is in their ground status (i.e., one is shared, one is learned by Director alone, and one is

new to both participants). The Director was instructed to identify the image on her screen with explicit instruction that there is no restriction on language (i.e., she can name or describe as needed), and the Matcher was tasked to click on the target image. The Matcher was also allowed to ask questions and interact freely with the Director as needed.

This procedure was followed for 24 test items: 8 Shared, 8 Alone, and 8 New targets. Half the targets in each ground status (n=4) are dog breeds; half (n=4) are kitchen items. Furthermore, half the dog items (n=2) are rare; the other half (n=2) are common; half the kitchen items (n=2) are rare; the other half (n=2) are common.

Each trial was recorded and the form of referring expression was coded as either Name Alone, Description, Name + Description, or Description + Name.

The data below are from 24 pairs of participants.

The Post-test

After the test phase, both participants individually took a post-test. Participants were asked to rate their partner's knowledge of each domain (dog breeds/kitchen utensils), as well as rate their own knowledge in the domain. Next, participants were shown a single item and were asked to type in the label for the item, if known, and rate their confidence in their label. They were also asked to rate their confidence that their partner would know the label for that object. This procedure was repeated for all test items as well as new items. These measures of confidence were implemented to measure general expertise as well as presumed relative expertise between the two participants (i.e., whether the Director was more knowledgeable than the Matcher, or vice versa) in order to assess knowledge asymmetry.

Lastly, they were asked to identify the context of learning the item: learned with partner, alone (applicable for director only), learned prior to the experiment, or never learned. The items tested varied in context of learning; they could be an item from shared learning, Director-alone learning, or New items. This measure was used to observe whether participants were tracking context of learning by specific item.

Results

We focus on speakers' Name-Alone use. We fit a GLM model predicting Name use against a single category combining other forms. Fixed effects were Commonality (Rare/Common), Ground Status (Privileged/Shared/New), and Knowledge Asymmetry (More/Less knowledgeable Matcher, as determined by post-test ratings) with Pair as a random effect (Table 1). Below we address our particular predictions.

Name ~ Asymmetry + Ground * Commonality + (1|Pair)	β	Std Error	P-value
AsymmetryM+	0.73	0.29	<0.01
AsymmetrySAME	-0.22	0.33	0.49
CommonalityRare	-3.36	0.43	<0.001
GroundShared	1.13	0.69	0.10
GroundNew	-1.53	0.42	<0.001
GroundPriv:CommonalityRare	-0.47	0.76	0.53
GroundNew:CommonalityRare	0.67	0.56	0.23

Table 1: GLM model ouput

Does the commonality of an object impact the effect of shared learning with a partner?

A main effect of Commonality demonstrates less name use for Rare than Common names ($p<0.001$). In regard to Ground status, speakers are less likely to use a Name when the item is New than when Shared ($p<0.001$), but for learned names, the main effect of Ground was not significant.

Figure 3 shows Name use by the speaker across Commonality and Ground. The main effect of commonality can be seen by the larger proportion of name use in the right three columns of the graph (Fig 3). Although there was no effect of Ground Status across learned items, when looking at Rare items in comparison to Common items, one can see that differences in name use across Ground status conditions are more apparent for Rare than Common objects, similar to results in past work with novel objects. Indeed, in separate models, effects of Ground were significant for Rare items, such that names are used less for privileged items than for shared items. Common objects show the same pattern but to a much lesser extent. Thus, the speaker is less likely to use names when referring to rare objects than common ones and this preference is further reduced if the rare objects are privileged or new.

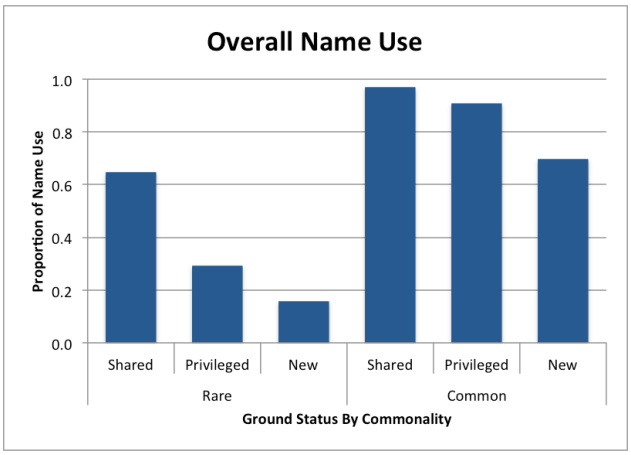

Figure 3: Overall use of names by the Director across Ground Status (Shared, Privileged, New) and Commonality (Common, Rare) conditions.

Does inferred expertise inform the speaker's choice of referring form?

A main effect of Asymmetry showed that speakers were more likely to use a Name when the Director presumes the Matcher to be more knowledgeable than herself ($p<0.01$)

Figure 4 shows Expertise effects across Ground Status and Commonality conditions. The main effect is shown by an overall larger proportion of name use when the Matcher is deemed more knowledgeable than the speaker (M+) than when the Matcher is deemed less knowledgeable (M-). These effects are carried most strongly in two conditions: for Rare objects that are learned together (Shared), and for Common objects that are New (not learned at all in experiment).

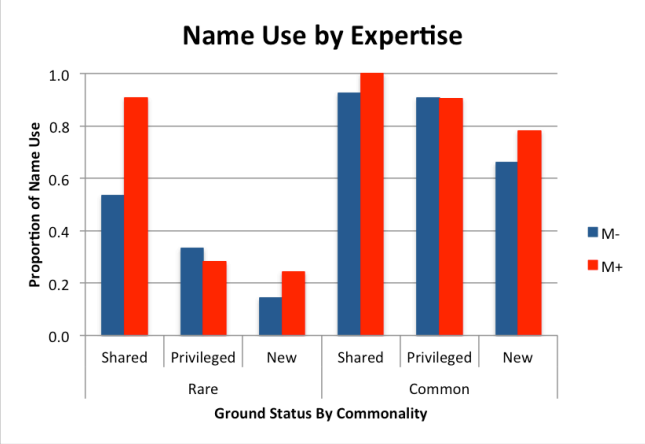

Figure 4: Proportion of Names when Matcher deemed more (M+) or less (M-) knowledgeable than the Director.

Data gathered from the post-test, in which participants had to identify the context in which a particular item was learned (e.g., alone, shared, or neither) revealed high accuracy for tracking ground status (Table 2). This measure was recorded to assess memory of ground status across the course of the experiment. Table 2 shows highest accuracy of context identification for Rare Shared items and lowest accuracy for Common Shared, but this is not significantly different across the categories.

Context Identification Accuracy (Post-Test)		
Common	Alone	86.1%
	Shared	85.4%
Rare	Alone	86.1%
	Shared	91.7%

Table 2: Post-test accuracy

Discussion

Speakers' choice of names is strongly affected by the prior likelihood that an interlocutor will know a name. When items are more common, shared learning has weaker effects on name use than when an object is rare. As in previous studies with novel objects, common ground effects are more apparent for less commonly known items. This is taken to show that a speaker's reliance on shared learning as a means to assess partner knowledge is reduced when the objects are likely to be commonly known. This provides evidence that the basis of common ground in an interaction relies on assessments of prior knowledge as well as shared experience. The strongest version of the memory-based account would expect ground effects regardless of commonality, as long as partners have shared experience. However, our post-test data show that speakers are highly accurate in identifying the context of learning, suggesting that they are not less sure about whether a name was shared but they are using that information in combination of other information: i.e, prior knowledge.

Furthermore, we see general expertise effects, such that name use is increased when the addressee is deemed to be more knowledgeable than the speaker. This provides evidence of dynamic updating of knowledge assessments. Future directions would include a more controlled way of assessing when exactly expertise judgments as this might help in teasing apart whether this is confined to the learning phase, or whether participants indeed continue to update beliefs throughout the test phase. However, even with assessments taken post test, we see expertise effects driven from interaction.

Having established expertise effects using this paradigm, we are currently carrying out follow-up work that uses the paradigm to explore further questions. For instance in an ongoing experiment we ask whether expertise assessments derived from the interaction are more strongly weighted than expertise assessments derived from top-down knowledge (e.g., telling the speaker his partner is an expert). Our current study asks this very question by having a director complete the collaborative task in the test phase without any prior interaction with her partner and given only top-down information about the partner's status as an expert in the domain.

Another avenue of research study explores the signals in the interaction that contribute to the assessments of expertise. Specifically, we are testing normed markers of uncertainty modeled on the types of utterances we observed during the learning phase. A confederate matcher will, in the learning phase, reveal her expertise through use of these uncertainty cues. If naïve directors attribute expertise to their partner as a function of these cues, it will be an important step in further understanding the particular components of an interaction that inform beliefs of partner knowledge.

Overall, the contribution of the current study is in embedding the previous evidence on shared experience into a larger computation of the likelihood of addressee knowledge. The effect of commonality on choice of referring expression may not be surprising on its own but together with evidence of inferences of expertise throughout the interaction, one can get a better understanding of how speakers may be combining these different sources of information to compute

this likelihood. Future studies will examine the factors that shift around the likelihood rather than to only appeal to low-level processes (i.e., memory traces) that contribute to the individual factors. We then can evaluate quantitative models to compare likelihood models that combine multiple cues with other classes of models.

Lastly, this study explores expertise in domains given interactions about particular items. We argue that the generalization of presumed expertise to a larger domain given updated beliefs about particular objects is tied to beliefs about groups of people and the presumed knowledge of particular communities. For example, dog kennel owners are likely to be presumed to know a lot of about dog breeds and not so much about cat breeds. However, if the relevant community were veterinarians, a member of that community might be presumed to know about both dog breeds and cat breeds. We argue that assessments about expertise are necessarily tied to the community applied, and this constraint is utilized by speakers to narrow in on the dimensions that are relevant for both generalization to new interlocutors and generalization to new items in a given domain.

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