Interpreting referential noun phrases in belief reports – the *de re*/*de dicto* competition

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Word count: 11,722

Abstract

The *de re*/*de dicto* ambiguity centers on the referential and/or attributive properties of noun phrases in the scope of intentional operators such as belief reports. For the belief report *Julie believes Elizabeth's poem will win the competition*, a *de re* reading of the embedded referential noun phrase *Elizabeth's poem* entails that the referential association between this noun phrase and the target poem is true from the perspective of the speaker but may not be registered as such in the belief holder's (i.e. Julie's) mind. In contrast, a *de dicto* reading describes Julie's beliefs as she registers the referential association in her mind. While both the *de re* and *de dicto* readings of definite noun phrases are judged acceptable given different supporting contexts, we show that the acceptability of *de re* readings is vulnerable to contextual and pragmatic manipulations. One such case involves a context in which a belief holder Julie holds a mistaken belief about the identity of the poem, for instance, by thinking that it was written by Nicole while in reality it was written by Elizabeth. This mistaken identity context introduces a *de dicto* reading of a competing noun phrase *Nicole's poem* in *Julie believes Nicole's poem will win the competition*. Under this context, the speaker-oriented *de re* reading of *Elizabeth's poem*

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has a roughly bimodal acceptability distribution, while the *de dicto* noun phrase was overall preferred. Our study is the first that systematically lays out the empirical landscape of *de re*/*de dicto* readings of definite noun phrases and points out the vulnerability of the *de re* reading. The investigation solidifies the foundation for further theory development and endorses the practice of collecting reliable empirical judgment data for nuanced semantic phenomena.

Key words: *de re*/*de dicto*, definite noun phrases, belief reports, linguistic judgment, experimental semantics, context effects

1. Introduction

The *de re*/*de dicto* distinction refers to an interpretive ambiguity of noun phrases embedded in an intensional domain[1]. For example, in (1), under a *de re* reading of the noun phrase *a prince*, Aurora wants to marry a particular individual who the speaker of (1) knows to be a prince. This is in fact the scenario in the first part of the story of *Sleeping Beauty*, in which Aurora falls in love with a man she meets in a forest who the narrator knows to be Prince Phillip, although Aurora herself is not aware of his royal station. In this scenario, someone can truthfully describe Aurora's desires with (1). However, this sentence also has another interpretation – the *de dicto* interpretation of the noun phrase *a prince*, in which Aurora's beliefs are characterized as, basically, wanting to marry a prince, whoever one might be. In the context of *Sleeping Beauty*, the same sentence under the *de dicto* interpretation is false because Aurora desires to marry only the man she met in the forest, thus she is not in the state of desiring to have a husband that is a prince.

(1) Aurora wants to marry a prince.

   a. True under the *de re* reading in the context of the *Sleeping Beauty* story

   b. False under the *de re* reading if Aurora did not want to marry Prince Phillip (and Prince

[1] As early as Aristotle, linguistic phenomena related to *de re*/*de dicto* have been observed. Yet this pair of Latin terms was not intensively applied until the Medieval period by Thomas Aquinas. The study of phenomena related to *de re*/*de dicto* in philosophy and linguistics can first be seen in G. Frege (1948), B. Russell (1905), and W.V.O. Quine (1956) even if none of them explicitly use the term *de re*/*de dicto* in their writings. The current senses of *de re* and *de dicto* may deviate a little from the literal Latin meaning of the terminology (*de re*: 'of the thing', *de dicto*: 'of what is said') (von Fintel & Heim, 2011), so it may be clearer to introduce the *de re*/*de dicto* distinction via contextualized examples. For more details of the nomenclature, see Keshet and Schwarz (2019).

Phillip is the only prince in the context)

c. True under the *de dicto* reading if Aurora were following expectations for royalty

d. False under the *de dicto* reading in the context of the *Sleeping Beauty* story

A classic approach in formal semantics to model the *de re*/*de dicto* distinction is via scope ambiguity (Partee et al., 1990; Quine, 1956; von Fintel & Heim, 2011, a.o.). As represented in (2a) for the *de re* reading of (1), the existential quantifier $\exists$ takes a wider scope than the universal quantifier $\forall$ over possible worlds associated with Aurora's desires; the property of being a prince that holds of the bound variable x is evaluated to be true in the actual world w_0; the event that Aurora marries x takes place in the possible worlds w' that are compatible with what Aurora wants in the actual world. On the other hand, for the *de dicto* reading in (2b), the universal quantifier $\forall$ over possible worlds takes a wider scope than the existential quantifier $\exists$, and the "prince" property is evaluated to be true in Aurora's desire worlds w'.

(2) a. $\exists x$ [prince$_{w_0}(x) \wedge \forall w'$ [WANT$_{w_0}(A,w') \rightarrow$ marry$_{w'}(A,x)$]] (*de re*)

b. $\forall w'$ [WANT$_{w_0}(A,w') \rightarrow \exists x$ [prince$_{w'}(x) \wedge$ marry$_{w'}(A,x)$]] (*de dicto*)

The scope approach that highlights the two readings by the scope interactions generates interesting implications. For the *de re* reading in (2a), since *prince* is evaluated outside the universal quantifier over the possible worlds associated with Aurora's desire, Aurora doesn't have to realize that x is a prince. The noun phrase *a prince* is just one of many possible referential terms that pick up the specific individual in the real world. For the *de dicto* reading in (2b), on the other hand, since *prince* is evaluated within the scope of *want*, the interpretation is that whoever Aurora wants to marry is a prince. Assuming Aurora only wants to marry one person, if she ever has someone who she wants to marry, that person should be a prince.

The *de re*/*de dicto* ambiguity has also been extensively studied in definite noun phrases with a scope analysis (Fodor, 1970; Nelson, 2019; Percus, 2000; Romoli & Sudo, 2009; von Fintel & Heim, 2011, a.o.). An example is (3) where the possessive noun phrase *your abstract* could have either a *de re* or a *de dicto* reading given the corresponding supporting context. Specifically,

the ambiguity hinges on whether the belief holder is aware of the possessive relation between the abstract and the addressee.

(3) John believes that your abstract will be accepted.

Evaluating context for De Re: John's belief may be about an abstract that he reviewed, but since the abstract is anonymous, he doesn't know who wrote it. He tells me about that abstract and he believes that it is sure to be accepted. I know that it is your abstract and inform you of John's opinion by saying the sentence above.

Evaluating context for De Dicto: You are a famous linguist that John is acquainted with. John knows your work very well and believes that you submitted a (unique) abstract to a linguistic conference. Given his general knowledge about this specific conference and his high opinion of your work, he believes that your abstract will be accepted, even if he doesn't know which one is your abstract or has read it. He tells me his belief and I am retelling the belief to you.

(von Fintel & Heim, 2011, p.157).

Following the scope solution for this basic ambiguity under simple contexts, more theoretical semantic tools have been proposed to capture the *de re*/*de dicto* ambiguity in syntactically different complement clauses, for different types of noun phrases, and under more sophisticated contexts (Charlow & Sharvit, 2014; Deal, 2018; Elliott, 2023; Keshet, 2008; Percus, 2000; Percus & Sauerland, 2003, a.o.). Diverging a little from, yet ultimately contributing to this path, in this paper, we utilize tools in experimental semantics (e.g. Cummins & Katsos, 2019) and investigate the contextual influence on the acceptability of *de re*/*de dicto* readings of definite noun phrases. The motivation behind going "experimental" is that despite the clear availability of *de re* readings of definite noun phrases in examples like (3), other examples in existing literature suggest that the acceptability of *de re* readings may vary in ways that suggest that features of the context may play a role (J. C. Anderson, 2013; Jaszczolt, 1997; Sudo, 2014; Zhang & Davidson, 2021). Given the field's growing interest in providing robust replicable linguistic evidence to support theoretical development (e.g. Davidson, 2020; Tonhauser & Matthewson, 2015, and see new conference venues

such as Experiments in Linguistic Meaning) as well as the limited experimental research on the topic of *de re*/*de dicto*, we believe it is crucial to understand more about the factors that influence under which contexts *de re* readings would be more (un)acceptable. We hope this line of research can further solidify the empirical foundation of the interpretation of noun phrases in intensional semantics.

The paper is structured as follows. In Section 1.1, we present claims of an asymmetry in the acceptability of the *de re* reading compared to the *de dicto* reading for definite noun phrases, among broader observations of both interpretations generally being available for noun phrases in the scope of intensional operators. In Section 1.2, we reinforce the motivation for experimental investigation and highlight the potential contribution of this study to linguistic theories. In Section 1.3, we lay out a finer-grained categorization of the *de re* permitting contexts and of the *de re*/*de dicto* ambiguity. We use these new categories to design well-controlled stimuli for empirical testing and causal analysis. In Section 1.4, we introduce the experiment outline. Then in Section 2 to 4, we report designs and results of three experiments. In Section 5, we raise potential explanations of the contextual effect on *de re* acceptability and conclude with an eye toward future work.

1.1 Diverging judgments of *de re* readings

In this section, we present existing literature suggesting that the *de re* reading of noun phrases embedded in intensional domains may be less acceptable or preferred in some contexts than a *de dicto* interpretation.

First, we see claims that argue for a preference toward the *de re* reading out of the *de re*/*de dicto* ambiguity from works in Default Semantics (Capone, 2011; Jaszczolt, 1999, 2005, 2015, a.o.). In this framework, where a main claim is that utterance meaning is jointly determined by its compositionality, the intention of interlocutors, and their cognitive biases in communication, Jaszczolt (1997) argues that the *de re* reading of definite noun phrases is the default and the most salient one, because the primary objective of communication is understanding the speaker's intention by securing the referent of the speaker's utterance in the conversational context. Since the *de re* read-

ing highlights the referential property of noun phrases and is able to select objects in the broader conversation context, it should stand out during interpretation. This *default de re* theory not only predicts the availability of *de re* interpretations but also predicts them to be even more accessible relative to *de dicto* during communication.

In a very different domain, namely legal studies, J. C. Anderson (2013) reports that the *de re*/*de dicto* ambiguity has been overlooked in the interpretation of legal statutes – the emphasis on *de re* readings of statutes and the lack of attention on the *de dicto* one have even led to puzzling judicial results[2]. For example, in the famous Enron Scandal in 2001, Enron's auditor Arthur Anderson anticipated litigation and urged its employees to destroy related financial documents. Their action stopped on the day when the U.S. Securities and Exchange Commission subpoenaed records. At that time, two federal obstruction statutes applied to document destruction. The more general statute makes it a federal offense to "corruptly...endeavor to influence, obstruct, or impede the due administration of justice."[3] The more specific one prohibits "knowingly...corruptly persuad[ing] another person...with the intent to...destroy an object...[or]...impair the object's...availability for use in an official proceeding."[4] The intentional words in these two statutes *endeavor* and *intent* grant each of the statutes a *de re* and a *de dicto* interpretation, as shown in (4) and (5).

(4) *De re* interpretations

(i) For the general statute: There is some X, which is in fact an instance of justice being administered. The defendant endeavors to influence or obstruct X.

(ii) For the specific statute: There is a specific official proceeding Y in which the defendant intends to impair some objects' availability for use.

(5) *De dicto* interpretations

(i) For the general statute: The defendant has the corrupt intention to influence what we describe as "the administration of justice" (J. C. Anderson, 2013, p.28).

(ii) For the specific statute: The defendant has the intention to initiate some kind of impair-

[2]For more legal cases where the bias towards *de re* reading influenced judicial results, see J. C. Anderson (2013).
[3]18 U.S.C. §1503 (2010)
[4]18 U.S.C. §1512(b) (2010)

ment against any possible official proceeding.

Because there was an overwhelming reliance among the judges on the *de re* interpretation of the two statutes and there was no sufficient evidence that suggests Arthur Anderson's destruction was under the knowledge of a *specific* pending proceeding, the defendant was not charged. What is worth noting is that the ruling could have been different had the *de dicto* reading been picked up. Anderson relies on children's difficulties in acquiring Theory of Mind (Apperly et al., 2010; Baron-Cohen et al., 1985; Wellman, 1992, a.o.) to back up her observation on the preference for *de re* over *de dicto* interpretations. That is, the observation that children tend to focus on reality and the broader context and find it difficult to reason about others' mind helps explain why (even) adults have a preference toward *de re* that emphasizes what is going on from the actual world and from the global context compared with *de dicto* that emphasizes mental status. This study in law cites different sources from the Default Semantics framework but arrives at similar conclusions on the empirical accessibility of the *de re*/*de dicto* ambiguity.

Finally, the evidence for a dispreference for *de re* comes from experimental findings reported in Zhang and Davidson (2021). They designed an acceptability task as exemplified in (6). The evaluating context featured a protagonist Julie who falsely associated the authorship of the target poem with Nicole but in reality and from the speaker's perspective, the poem was written by Elizabeth. According to a similar scenario in Romoli and Sudo (2009)[5], the belief report with the noun phrase *Nicole's poem* should be interpreted *de dicto* and the one with *Elizabeth's poem* should be *de re*.

(6) *Evaluating Context*: Julie is one of the judges of an ongoing poetry competition. The best poem that she has read so far is an extremely intriguing poem about the ocean. She believes

[5]The example in Romoli and Sudo (2009) is shown in (i). The context explicitly shows that the belief holder does not think the *de re* noun phrase refers to the target individual because the belief holder registers the *de dicto* term as associated with the target individual.

(i) John thinks that the president of the United States is smart.
Evaluating context: Consider the situation as of today [2009], in which Barack Obama is the president of the United States, and suppose that John wrongly thinks that Al Gore is. In this context, the sentence has two interpretations. It can be read as reporting John's belief about Barack Obama or about Al Gore. The former is called the *de re* reading and the latter the *de dicto* reading.

that this poem will win the competition. Julie remembers being told that Nicole, one of the best-known poets, submitted a poem about the ocean to the competition. Therefore, Julie concludes that this poem must be written by Nicole and the first prize will be going to her. However, this poem was actually written by Elizabeth, a younger and lesser-known poet. It is just a coincidence that the two poets wrote about the same topic.

a. Julie believes that Nicole's poem will win the competition. (*de dicto*)

b. Julie believes that Elizabeth's poem will win the competition. (*de re*)

In Zhang and Davidson (2021)'s experiment, speakers of English read four stories similar to (6). Two stories had the follow-up test sentence with a *de re* reading and the other two stories had a sentence with a *de dicto* reading. Participants used a continuous slider bar to give their judgment. Transforming the judgment data into the sides of agreement and disagreement, the results show that around 20% of participants disagreed with both *de re* sentences, about 40% disagreed with one of the *de re* sentences, and the rest of 40% of the participants agreed with both *de re* sentences. In contrast, almost all of the participants showed strong agreement with the *de dicto* sentences. What is more outstanding is that a sizable proportion of the disagreement against *de re* aggregated on the very edge of the slider bar. In contrast, the majority of the *de dicto* judgments aggregated on the edge of the agreement side. This empirical finding, especially the peculiar bimodal distribution of *de re* acceptability, is surprising in light of other work such as Romoli and Sudo (2009) where both readings are predicted to be generally acceptable.

Thus we see several different sources in the literature that seem to report greater easiness or difficulty, respectively, in accessing *de re* readings in comparison to *de dicto* readings of noun phrases. This seems like an area ripe for more careful experimental consideration, especially further investigation of the role that context and pragmatics may play in these judgments.

1.2 More motivations for experimental investigation

Given some reported disparities in existing literature between *de re* and *de dicto* interpretations, more carefully controlled experimental research seems prudent; in this section we further motivate

an experimental take on this topic.

For one thing, from the perspective of research methodology, the experimental investigation on *de re*/*de dicto* provides an instance that enriches the discussion on "the nature of empirical evidence in research on meaning" (Tonhauser & Matthewson, 2015, p.1). To yield stable replicable and transparent data for theoretical development, Tonhauser and Matthewson (2015) argue that one needs to provide not only the linguistic expression under investigation but also the context in which the expression is uttered, a response by a native speaker to a task involving the linguistic expression in the context, and information about the native speakers that provide the response. Gibson and Fedorenko (2010) also argues for using multiple items with controlled experiments to eliminate confounding factors like specific lexical properties in a single sentence and idiosyncrasies from the contexts (aspects of experimentation that are valuable even in very small scale studies, as discussed in Davidson (2020)). Existing research in semantics and pragmatics has already found valuable insights from studying the influence of contexts, experimental paradigm, and/or response options on linguistic judgments and therefore illustrated advantages to become more "experimental" (see, e.g. Schwarz et al. (2007) and Jasbi et al. (2019) for scalar implicature and the influence of contexts as well as response options; see Jasbi, Bermudez, and Davidson (2023) and Jasbi, Bermudez, Zhang, et al. (2023) for logical connectives and the effect of experimental paradigm on cross-linguistic findings). Our research is another case study that advocates for rigorous experimental practice in the study of meaning.

Second, empirically investigating the *de re*/*de dicto* reading acceptability provides a case study of how formal theories of meaning that involve logic and mathematical techniques align with psycholinguistic findings that delineate the psychological representation of meaning. For example, it would be interesting to explore whether there is an analogy between (i) the semantic representation of the *de re*/*de dicto* ambiguity with the formal scope technique against its empirical acceptability and (ii) the formal quantificational scope and the related psycholinguistic processing mechanisms in classic scope interactions (see Brasoveanu & Dotlačil, 2019, for a review). We know that the inverse scope reading is sometimes hard to obtain, as in (7) (e.g. C. Anderson, 2004; Tunstall, 1998).

What is more interesting is whether a wider existential scope in *de re* that is opposite to its surface position also leads to interpretation or processing difficulty.

(7) a. A caregiver comforted Mary every night. (The inverse scope reading is, at every night, there was a different caregiver who comforted Mary.)

b. A boy climbed every tree. (The inverse scope reading is, for every tree, there is a different boy who climbed it.)

Last but not least, the *de re*/*de dicto* ambiguity in belief reports is one of many phenomena that investigate the cognitive relation between people and propositions (see Nelson, 2023, for a review). It tries to answer how one's belief is encoded in language, and in turn, how the ambiguity of language leads to varied and nuanced interpretations of one's belief content. It has attracted interdisciplinary discussion from philosophy (e.g. Cohen et al., 2021; Epstein et al., 2023; Lederman, 2022; Richard, 1990), cognitive science (e.g. Apperly & Robinson, 2003; Robinson & Apperly, 2001), and even artificial intelligence (e.g. Wiebe & Rapaport, 1986; Wu et al., 2023). Understanding what contexts facilitate or impede a certain reading of the belief report could shed light on the research agenda that aims to understand the relation between language and mind. More practically, this line of research could also complement existing research about false belief tasks and Theory of Mind (e.g. Baron-Cohen et al., 1985; Wimmer & Perner, 1983) where the focus has been on the predicate of the belief content (e.g. *Sally believes that the marble is in the box.*) rather than the referential properties of noun phrases (e.g. *the marble*) inside belief reports.

1.3 A finer-grained categorization of *de re* contexts and the *de re*/*de dicto* term

In this section, we set up a finer-grained categorization of (i) the *de re* permitting contexts and (ii) the *de re*/*de dicto* terminology to better operationalize our experimental investigation. The aim is to collect accurate linguistic judgments for a specific linguistic expression with a clarified meaning in a well-controlled context.

First, we categorize the *de re* permitting contexts into two types: the "ignorance" context and the "misapprehension" context, adopting the terminology introduced by Sudo (2014). The misap-

prehension context in Sudo (2014) is shown in (8) where the attitude holder is wrong about the identity of the referent, though he does not give an ignorance context example.

(8) John thought that the linguist was nervous.

Evaluating context: John interviewed two girls, Mary and Sue. He was informed beforehand that one of them is a linguist, but was not told which. We know that Sue is the linguist. After the interviews, John wrongly concluded that Mary was the linguist, because she said she speaks five languages. John thought that Sue was nervous.

In general, the misapprehension context applies to cases where the belief holder is wrong about the identity of the referent and assigns to it a noun phrase that is true in the belief holder's mind but false in reality. The *de re* context in the "poetry competition" example in (6) features such a misapprehension context. Judge Julie believes the poem was written by Nicole and assigns the noun phrase *Nicole's poem* to it. But in reality and the broader story context, the poem was written by Elizabeth (the latter noun phrase *Elizabeth's poem* is read *de re*). On the other hand, the ignorance context applies to cases where the belief holder is ignorant of the association between the *de re* noun phrase and the referred object. The context in the "abstract reviewing" example in (3) that permits the *de re* reading can be categorized as the ignorance context since the belief holder John is not aware that the abstract was written by the addressee.

Consistent with most formal semantics literature on the ambiguity, Sudo (2014) does not predict or discuss differences in the acceptability of the *de re* interpretation of definite noun phrases between these two contexts. Yet in Zhang and Davidson (2021), the judgment data shows that the misapprehension context prioritizes *de dicto* and disfavors *de re*. One potential hypothesis is that the misapprehension context highlights the contrast between the belief holder's mental state and the story's broader context. When the target sentence *Julie believes that Nicole's poem*$_{de\ dicto}$ *will win the competition* starts with *Julie believes...*, it highlights the belief holder's mental state. Since the *de dicto* term is consistent with the content of the belief holder's mind and thus is consistent with the preamble, it is prioritized against the *de re* noun phrase. Previous research on children's interpretation of belief reports shows that highlighting the belief state of the protagonist in the con-

text increases the likelihood that children attend to the belief content (Lewis et al., 2017). It is thus interesting to see whether the same mechanism is playing a role in the disproportionate judgment pattern in *de re*/*de dicto* noun phrases.

Secondly, we adopt a three-way distinction of the *de re*/*de dicto* ambiguity as referential *de re*, referential *de dicto* and attributive *de dicto*. This is motivated not only by the fact that ontologically two types of contexts emerge under the umbrella of *de dicto* for definite noun phrases but also that from an experimental perspective, we could have a better control over what context corresponds to what specific readings of the sentence. Based on previous discussion around the referential and attributive properties of definite noun phrases (Donnellan, 1966; Fodor, 1970; Jaszczolt, 1997), we introduce this tripartite taxonomy using the "poetry competition" example, repeated here as (9)[6].

(9) Julie believes that Elizabeth's poem will win the competition.

The context that assigns Elizabeth's poem a referential de re reading: Julie does have a particular poem in mind that she believes will win the competition. However, Julie doesn't recognize the description *Elizabeth's poem* as a description of the poem she has in mind.

The context that assigns Elizabeth's poem a referential de dicto reading: Julie does have a particular poem in mind that she believes will win the competition. She has the poem in mind as *Elizabeth's poem*. However, in reality, the poem is Nicole's poem. In other words, Julie falsely represents the poem by using a referential term that is false in the actual world.

The context that assigns Elizabeth's poem an attributive de dicto reading: Julie does not have any particular poem in mind but simply believes that whichever poem written by Elizabeth will win the competition.

We can achieve a precise and finer-grained understanding of how the distinction of *de re*/*de dicto* in definite noun phrases can be mapped to specific readings under specific contexts by integrating the two context types and the three readings of intensional definite noun phrases. The ignorance

[6]Note that there is a fourth reading here: Julie believes that poem A will win the competition and knows that poem A was written by Elizabeth. This reading is not controversial and less interesting from a theoretical sense so we didn't put it in parallel with the other three. More nuanced readings are pointed out in the literature, such as *Elizabeth* is *de re* but *poem* is *de dicto* (Charlow & Sharvit, 2014) or the term "third" and "forth" reading in Fodor (1970). We do not touch upon those readings for now.

context only permits a referential *de re* reading of the corresponding definite noun phrase. The misapprehension context (theoretically) permits a referential *de re* reading of one definite noun phrase and a referential *de dicto* reading of another (competing) definite noun phrase. The following experiments aim to test whether the division of context types and terminologies can help address the bimodal distribution of acceptability judgments of *de re* reported in prior work by Zhang and Davidson (2021).

1.4 Experiment outline

This section introduces the outline of three experiments. All three experiments adopted an acceptability task with adult native speakers of English.

Experiment 1 replicated Zhang and Davidson (2021) and found that while the context featured misapprehension and allowed a referential *de re* reading for one noun phrase and a referential *de dicto* reading for another, the referential *de re* reading did show a bimodal distribution of acceptability judgments.

Experiment 2 put the critical sentence from Exp.1 under contexts that supported only an attributive *de dicto* reading (as the control context) and contexts that only supported a referential *de re* reading (as the ignorance context). There, we found no statistical difference in acceptability ratings between both readings – both received high agreement. This shows that the (referential) *de re* interpretations of belief reports are acceptable in the ignorance contexts.

Experiment 3 tested the hypothesis that the misapprehension context, i.e. the co-existence of a referential *de re* definite noun phrase and a referential *de dicto* definite noun phrase in the same context, would make the former reading less acceptable. By juxtaposing the misapprehension context from Experiment 1 and the ignorance context from Experiment 2, we found evidence supporting this hypothesis.

In sum, we show that while the *de re* reading of definite noun phrases is undoubtedly allowed by the grammar, its acceptability is vulnerable to contextual factors relating to competition between multiple possible referential expressions. When a competing referential *de dicto* appears in the

same context, in other words, when the belief holder associates a wrong term with the target object, the *de re* reading with a different term becomes much less acceptable. We discuss the potential mechanisms and implications in Section 5.

2. Experiment one

Experiment 1 aims to replicate Zhang and Davidson (2021), asking whether the bimodal distribution of *de re* judgments found in this existing study would persist with another round of testing with slight modifications of response type that will be used in the rest of the studies in this paper.

2.1 Methods

2.1.1 Participants

60 participants who self-identified as English monolinguals from the United States (aged 39.15 ± 12.05) took this study. They were recruited from the online crowdsourcing platform Amazon's Mechanical Turk and were paid $2.00 for their participation.

2.1.2 Materials & procedures

Since Experiment 1 was a replication of Zhang and Davidson (2021), the experimental materials were the same as theirs. The only difference was that we adopted a discrete fully-labeled Likert scale to collect the judgment rather than a continuous slide bar in the original study. We chose a Likert scale over a binary option or a continuous slider based on the following considerations: First, Likert scales provide finer-grained levels to reveal potential judgments that would otherwise remain concealed on a binary scale (e.g. Jasbi et al., 2019; Katsos & Bishop, 2011; Zhang et al., 2021) and can achieve the same statistical power with a smaller sample size (Cremers et al., 2023); second, the labels at the intermediate levels (e.g. "somewhat agree", "uncertain", "somewhat disagree") potentially offer better interpretability than a continuous slider bar when it comes to mapping participants' intermediate choices with their actual interpretations; third, choosing Likert scale does

not lose significant sensitivity compared with the continuous slider bar (Marty et al., 2020; Sprouse & Almeida, 2017).

As for the specific experimental design, participants read four stories (113 ± 6.4 words) in a Qualtrics survey and gave their acceptability judgments on a subsequent target declarative sentence in terms of how accurately each sentence reflected the facts in each story. The story and the sentences appeared on separate pages. There was no time pressure to complete the experiment. Participants could return to any story and change their answers at any time before submitting their answers.

Each story portrayed a protagonist who holds a belief toward a person or object (we simplify this using "entity"). The story fosters a misapprehension context where the protagonist falsely attributes one definite noun phrase to refer to the target entity but in reality, the correct attribution should come from the other definite noun phrase. One of the trials is shown in Table 1[7] which is the same as (6). Julie falsely believes the poem was written by Nicole. In reality, it was written by Elizabeth, which Julie is unaware of. Given this context, the target sentence to be judged featured a report describing the protagonist's belief. The experimental manipulation concerned what definite noun phrase to be used in the belief report as the referring expression. Using the definite noun phrase held true in the protagonist's mind would render the belief report a referential *de dicto* reading. In contrast, using the definite noun phrase held true in the broader story context and from the speaker's perspective would render the report a referential *de re* reading. In theory (Romoli & Sudo, 2009; Sudo, 2014), both readings are predicted to be true.

Additionally, for each story, there were three sentences accompanying the target sentence as fillers and controls; of these one was true given the context, one was false, and the third one was undecided because of the lack of verifying information. For each sentence to rate, participants were asked to map their judgment onto a five-point fully labeled Likert scale. Participants gave their judgment depending on whether and to what degree they agreed with the content of the sentence given the story context. By comparing the proportion of different levels of agreement between

[7]The critical sentences that determined the condition were italicized in the table for illustration purposes. They were not italicized in the actual experiment.

Table 1: Example story from Experiment One.

Context Julie is one of the judges of an ongoing poetry competition. The best poem that she has read so far is an extremely intriguing poem about the ocean. She believes that this poem will win the competition. Julie remembers being told that Nicole, one of the best-known poets, submitted a poem about the ocean to the competition. Therefore, *Julie concludes that this poem must be written by Nicole and the first prize will be going to her. However, this poem was actually written by Elizabeth, a younger and lesser-known poet*. It is just a coincidence that the two poets wrote about the same topic.
Instruction According to this story, please indicate to what extent you agree or disagree with the following statements.
Target sentence Condition 1 Julie believes that **Nicole's poem** will win the competition. **(Referential *de dicto*)** **Target sentence Condition 2** Julie believes that **Elizabeth's poem** will win the competition. **(Referential *de re*)** Highly Disagree | Somewhat Disagree | Uncertain | Somewhat Agree | Highly Agree ○ ○ ○ ○ ○

conditions, we expected to approximate the representative judgment distribution of the two belief report versions.

Altogether each participant read four stories. We chose four items because this number was chosen in Zhang and Davidson (2021) and it was easier to compare item difference with a smaller set of scenarios at the initial stage of the *de re*/*de dicto* investigation agenda.

Furthermore, the condition manipulation was within-subjects and participants read stories in both conditions. Across the four stories, two were randomly assigned to be referential *de dicto* and the other two were referential *de re*. The order of stories and the sentences within a story were randomized. To achieve a Latin Square design, we manually created six lists[8] and each participant was randomly assigned to one of the lists. During the actual experiment, participants started by completing three practice trials (sentences to be judged without contexts) to familiarize themselves with the experiment design. In the end, participants completed a survey and provided their demo-

[8]We created six lists because there are six combinations where two stories are randomly interpreted *de re* and the other two are *de dicto*. That is {AB/CD, AC/BD, AD/BC, BC/AD, BD/AC, CD/AB} where the first two stories corresponded to a referential *de dicto* condition and the latter two corresponded to a referential *de re* condition.

graphic information and their self-reported linguistic profile (e.g. reading and writing proficiency, knowledge of other dialects/languages).

2.2 Results

We only analyzed the judgments from participants who passed the practice trials and whose judgments of the fillers were correct more than 75% of the time, so 51 out of 60 participants (85%) contributed their data to our final analysis[9].

Figure 1 shows that in the referential *de dicto* condition, the majority of judgment goes to the "highly agree" side. This contrasts with the referential *de re* condition where around 25 % of the judgments are "highly disagree" with the majority of choices still going to "highly agree".

We fit the judgment data into Bayesian multilevel cumulative ordinal models using the *brms* package (Bürkner, 2017, 2018) in R. The five-point judgments were the dependent variable with non-equidistant intervals between levels on the Likert scale. They were coded from 1 to 5 where 1 indicated "highly disagree" and 5 indicated "highly agree". The two critical condition levels were entered as a dummy-coded fixed effect (reference level = referential *de dicto*). The story was also entered as a fixed effect, and the interaction between the two fixed effects was also included.[10] Random intercepts and slopes for the full fixed effect structure for the subjects were included as random effects to obtain the maximal random effect requirements for mixed-effects models (Barr et al., 2013). The prior distributions for all the intercepts and coefficients of fixed effects were fitted to a normal distribution with the mean as 0 and the standard deviation as 2 (i.e. $Normal(0, 2)$); the prior for the correlation matrices was set to be $LKJ(2)$ (LKJ has been the default weakly informative prior for correlation matrices in *brms* (Lewandowski et al., 2009; Nalborczyk et al., 2019)); the variances for the correlation matrices were set as the default in R. The priors mildly restricted the possible coefficient for each parameter but still allowed reasonably large variance.

[9]The reason why we included the practice trials in the participant screening procedure was that we explicitly asked the participants to choose, e.g. "highly agree", over other choices. A failure to do so indicated a lack of attention to our materials and instructions.

[10]We consulted a statistician from our funding institution and took his suggestion to treat the story (N=4) as a fixed effect. Another motivation was that we could derive more insights into story-specific effect on the acceptability of *de re* reading from the statistical analysis.

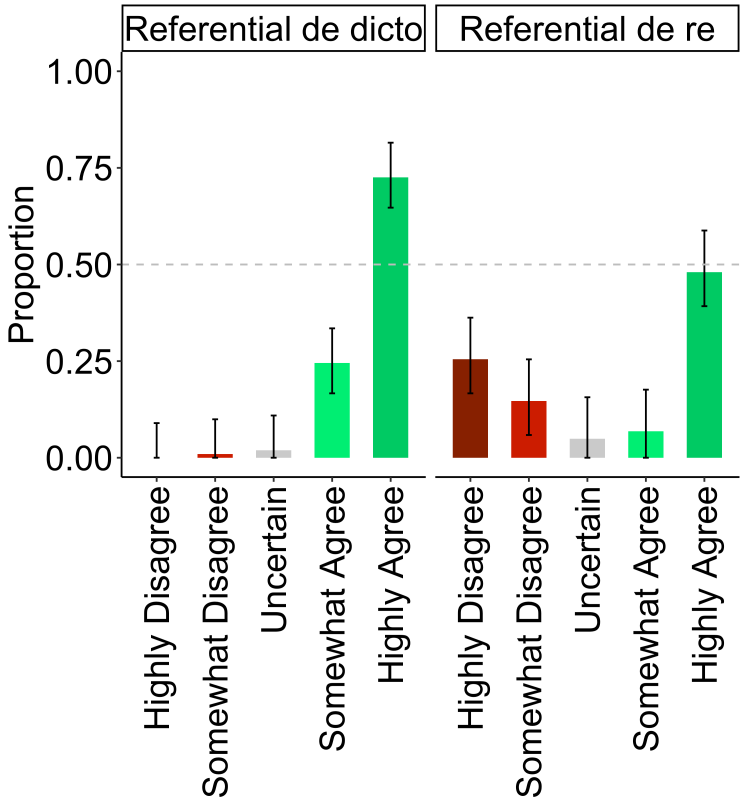

Figure 1: Proportion of different Likert scale choice in the referential *de dicto* and the referential *de re* condition (The 95% CIs were output from the *MultinomialCI* package (Sison & Glaz, 1995)).

The model had four sampling chains each with 4000 iterations. The first 2000 samples were taken as a warmup. An $\hat{R}$ close to 1.0 marks the convergence of the sampling chain to the underlying posterior distribution of the target predictor (Gelman & Rubin, 1992). The parameter setup also followed previous acceptability rating tasks in psycholinguistics (e.g. Paape et al., 2020; Zhang et al., 2023).

All $\hat{R}$s for the sampling chains for all fixed effects were 1.0, indicating successful convergence. We used the package *emmeans* (Lenth et al., 2018) to evaluate the main effect exerted by the *de re*/*de dicto* manipulation and the judgment distinction in each story setting. Here we use β to refer to the coefficient estimate and HPD, i.e. highest posterior density, to refer to the shortest interval with the highest density in the posterior distribution of target coefficient (Box & Tiao, 2011).

Overall, the referential *de dicto* condition receives more agreement than the referential *de re* (β

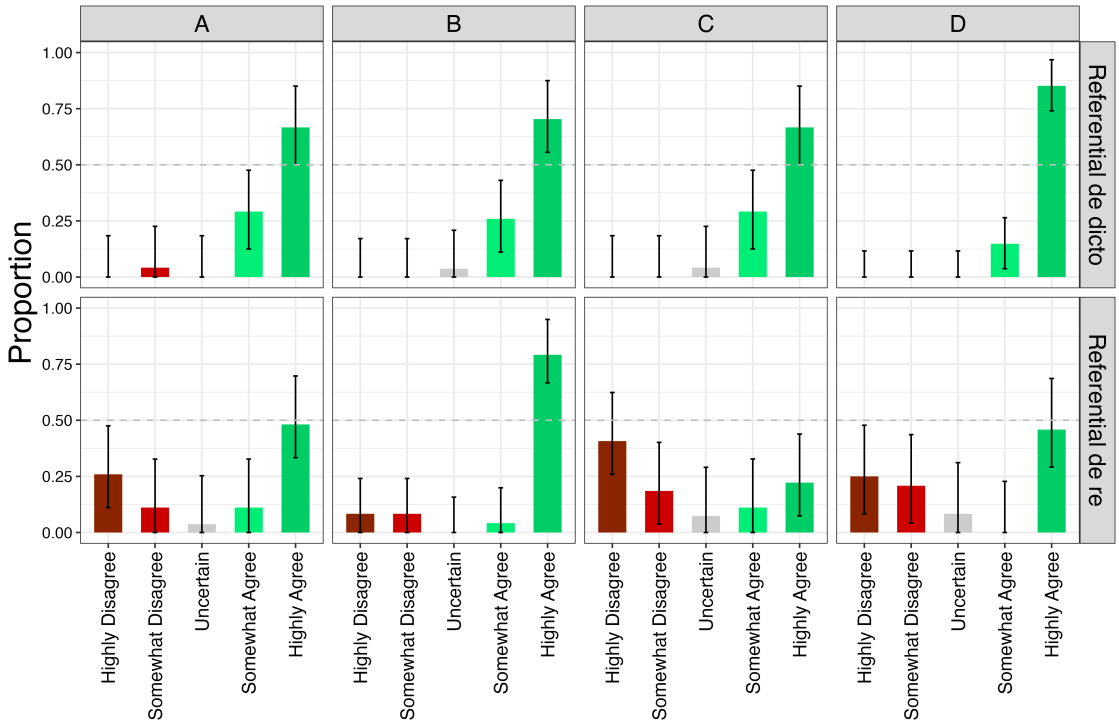

Figure 2: Judgement distribution across the four stories in Experiment One.

= 1.66, HPD = [0.16, 3.12]). Interestingly, the agreement distribution of the two conditions varied by the story: in story A, there doesn't seem to be a difference (β = 1.40, HPD = [-0.16, 2.99]); neither does story B (β = -1.30, HPD = [-3.84, 0.95]); in both story C and D, the referential *de dicto* reading is rated as more agreeable than the referential *de re* reading (C: β = 3.48, HPD = [1.33, 5.98]; D: β = 3.10, HPD = [0.65, 5.68]). The by-item distribution can also be seen in Figure 2.

When it comes to individual differences, we see that for the referential *de dicto* condition, more than 50% participants chose "Highly Agree" for both trials; nobody chose "Highly Disagree" and only one chose "Somewhat Disagree" once. In comparison, only 15 out of 51 participants (29.4%) chose "Highly agree" twice for the referential *de re* condition; 5 (9.8%) chose "Highly disagree" twice. It is clear that participants showed more disagreement and chose more intermediate options for the referential *de re* readings.

2.3 Discussion

In this experiment, we made use of contexts that should support, through two possible means of description, both the referential *de dicto* interpretation and the referential *de re* interpretation of belief report and varied the target sentence to gauge the judgment distribution of the two readings. We found that while the referential *de dicto* reading was overwhelmingly agreed upon, the referential *de re* led to a bimodal pattern of judgments. This successfully replicated Zhang and Davidson (2021) but raised judgment patterns that are new with respect to other experimental literature on this topic, such as Sudo (2014).

The by-item investigation shows that while all four stories received almost identical rating patterns for the referential *de dicto* reading, they exhibited different patterns for the referential *de re* reading. Specifically, in story B, the proportions for "Highly Disagree" and "Somewhat Disagree" were the lowest by comparison, replicating the finding in Zhang and Davidson (2021). We speculate that the unique judgment pattern for the *de re* sentence in story B, i.e. *Mrs. Jackson believes that Grace's gift was sent by Mike*, might be related to the information structure of the passive complement clause (see Appendix A for the complete experimental details). Since passives could (i) highlight the relative newness of the information in the *by* phrase – it was Mike, not someone else, who sent the gift, and/or (ii) emphasize that the subject is affected by the action denoted by the verb – the gift was sent not received (Ambridge et al., 2016; Pullum, 2014), this passive construction could potentially modulate the information flow so that readers might focus on verifying information in the predicate and ignore the subject part in the belief report. Nevertheless, story D also featured a passive structure in the complement clause, i.e. *Tracy believes that Alice's spare apron needs to be washed*, but there is still a significant proportion of disagreement on *de re*. We speculate that the *by* phrase in story B could play a role here and we leave to future work for more investigation on the effect of passives as well as the information structure of the complement clause on the judgment of the referential *de re* reading.

The investigation of individual differences shows that while more than half of the participants had no problem with accessing the referential *de dicto* condition, only 30% did so with the refer-

ential *de re* condition plus a 10% going for the opposite truth-value judgment.

In sum, the bimodal distribution of *de re* was replicated and observed to be systematic. Future studies are needed to disentangle the effects of linguistic information structure and individual differences on *de re* judgments.

3. Experiment two

It is clear that the contexts theoretically permitting the referential *de re* in Experiment 1 featured misapprehension of the belief holder and in this sense differed from the common *de re* contexts that usually feature an ignorance context (e.g. the *Sleeping Beauty* case in (1) and the conference abstract case in (3)). Besides, to our best knowledge, there has been no experimental research that lays out the judgments of the canonical *de re*/*de dicto* paradigm in a systematic way. Therefore, to collect judgment under a simple canonical *de re* permitting context, with the canonical *de dicto* permitting context as a comparison, Experiment 2 juxtaposed a context that only permits a referential *de re* reading of a definite noun phrase with another context that only permits the attributive *de dicto* reading.[11]

3.1 Methods

3.1.1 Participants

66 participants took this study who self-identified as English monolinguals from the United States (aged 32.94 ± 10.25). They were recruited from the online crowdsourcing platform Prolific and were paid $2.00 ($12-15/hr) for their participation.

3.1.2 Materials & procedures

The experimental design and materials were very similar to Experiment 1 except that the manipulation took place in the context, not at the sentence level and each context only theoretically

[11] The reason we tested the attributive *de dicto* instead of the referential *de dicto* reading of definite noun phrases in Experiment 2 was that the attributive one resembles the *de dicto* reading of an indefinite noun phrase, which is closer to the canonical interpretation of *de dicto* (please compare (1) and (9)).

permitted one reading. Additionally, the readings to be tested were attributive *de dicto* and referential *de re*. Each story (81.14 ± 13.75 words) portrayed a protagonist who held a belief. The target sentence to be judged featured a belief report. We created two conditions, the attributive *de dicto* condition and the referential *de re* condition, by varying the context of the story in which the same target sentence was to be evaluated. Table 2 exhibits an example and the full list of the materials is in Appendix B. In the attributive *de dicto* condition, the protagonist Julie believes that whichever poem written by Elizabeth will win – the noun phrase *Elizabeth's poem* does not refer to any specific individual entity in the mind of the speaker, only the contents of Julie's mind. In the referential *de re* context, Julie believes of a particular poem (that exists, according to the speaker) that it will win the competition but does not know that the authorship of this poem belongs to Elizabeth. The *de re* context in Experiment 2 was the ignorance context. Additionally, for each story, there were three sentences accompanying the target sentence as fillers and controls; of these one was true given the context, one was false, and the third one was undecided because of the lack of verifying information.

For each sentence to rate, participants were asked to map their judgment onto a five-point fully labeled Likert scale. Crucially, the condition manipulation was within-subjects and participants read stories in both conditions. Across the four stories, two were randomly assigned to be attributive *de dicto* and the other two were referential *de re*. The randomization, the counterbalance treatment, and the experimental procedure were the same as in Experiment 1.

3.2 Results

We only analyzed the judgments from participants who passed the practice trials and whose judgments of the fillers were correct more than 75% of the time. As a result, 60 (90.9%) participants contributed to the analysis.

Figure 3 shows that in the attributive *de dicto* condition, more than 75% of the judgments fall within the "highly agree" category and the distribution is strongly skewed towards the agreement edge. In the referential *de re* condition, more than half of the judgments aggregate to the "highly

Table 2: Example story from Experiment Two

Condition 1: Attributive *De Dicto* Julie is a judge of an ongoing poetry competition. She is told that Elizabeth Johnson, one of the best-known poets in the US, submitted a poem to the competition. Julie is a huge fan of Elizabeth. Even though Julie is blind to the authors and does not know which poem is written by Elizabeth, *she believes that no matter which poem Elizabeth submitted, it will win the competition*.
Condition 2: Referential *De Re* Julie is a judge of an ongoing poetry competition. *She encounters an extremely well-written poem and believes that this poem will be the winner of the competition*. This poem happens to be written by Elizabeth Johnson, a well-known poet in the US. But unfortunately, as a judge, *Julie is blind to the authors and therefore does not know it is Elizabeth Johnson who wrote this excellent poem*.
Instruction According to this story, please indicate to what extent you agree or disagree with the following statements.
Target sentence Julie believes that Elizabeth's poem will win the competition. Highly Disagree ○ Somewhat Disagree ○ Uncertain ○ Somewhat Agree ○ Highly Agree ○

agree" category with a similar skewness pattern. By visual comparison, the proportion of judgments from "highly disagree" to "somewhat agree" in the *de re* condition is slightly larger, indicating that the *de re* interpretation might be less acceptable, although in general both readings are overwhelmingly acceptable.

We fit the judgment data into Bayesian multilevel cumulative ordinal models. The condition, the story, and their interaction were entered as fixed effects; random intercepts and random slopes for the full fixed effect structure for the subjects were entered as random effects. The prior setting as well as all the other parameters were the same as in Experiment 1.

The Bayesian model shows that all $\hat{R}$s for the sampling chains for all fixed effects were 1.0, indicating successful convergence. There was no difference between the attributive *de dicto* condition and the referential *de re* in their agreement distribution (β = 0.825, HPD = [-0.18, 1.76]) and only in story A was there a difference in judgment of the two conditions (β = 1.31, HPD = [0.069,

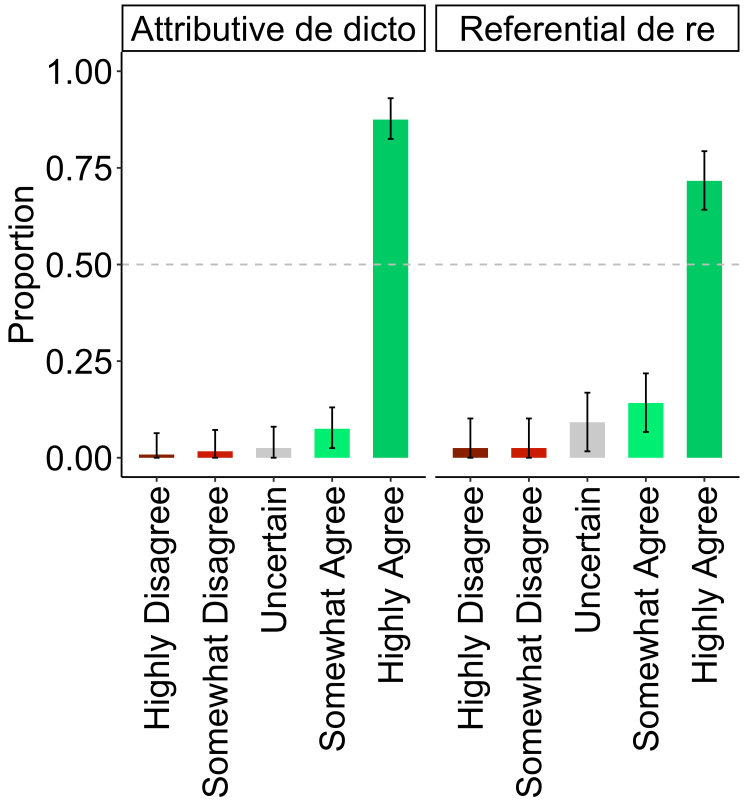

Figure 3: Proportion of different Likert scale choice in the attribute *de dicto* and the referential *de re* condition. (Error bars indicate 95% multinomial confidence intervals calculated by the R package *multinomialCI*).

2.63]).

3.3 Discussion

Experiment 2 found no statistical difference between the referential *de re* reading and the attributive *de dicto* reading of the definite noun phrase in the belief reports. This is consistent with prior literature and the general agreement in the field about the *de re*/*de dicto* ambiguity of noun phrases in belief reports. The comparison between Experiment 1 and 2 reflects that the unacceptability of the *de re* reading of definite noun phrases is conditional on the context. More specially, we know that the *de re* context in Experiment 1 featured the misapprehension of the belief holder while the *de re* context in Experiment 2 featured the ignorance of the belief holder with the *de re* expression.

4. Experiment three

Experiment 3 was designed in order to more directly test whether the *de re* reading of definite noun phrases was degraded in the misapprehension context compared to the ignorance context. To do so, we juxtaposed contexts that only supported the referential *de re* reading as in Experiment 2 (the ignorance context) and contexts that should theoretically support both the referential *de dicto* and *de re* reading as in Experiment 1 (the misapprehension context) in a within-subjects design. In both conditions, participants were asked to just rate the sentence with the *de re* interpretation. If this specific context setup affects the acceptability of *de re*, we would expect that in contexts that mirrored Experiment 1, the bimodal distribution would still persist; in contexts that mirrored the *de re* condition in Experiment 2, there would be no to few disagreements for the *de re* readings.

4.1 Methods

4.1.1 Participants

60 participants who self-identified as native speakers of English from the United States (aged 33.02 ± 8.35) were recruited from Prolific. They were paid $2.00 for their participation.

4.1.2 Materials & procedures

Table 3 shows an example story. In the referential *de re* condition (the ignorance context), there is only one valid nominal expression referring to the target object but the belief holder is unaware of such relation; the scenario only supports a referential *de re* interpretation of the belief report. In the referential (*de dicto* + *de re*) condition (the misapprehension context), there are two valid nominal expressions: one is interpreted *de re* that the protagonist is unaware of and the other is referential *de dicto* which the protagonist associates with the object in her mind but is wrong in the broader story context. Please see the full list of materials in Appendix C.

With this context manipulation, participants read the story and judged the following belief report where the nominal expression inside the belief report was *de re*. There were four scenarios. The

Table 3: Example story from Experiment Three.

Condition 1: Referential *de re* Julie is a judge in an ongoing poetry competition. She encounters an extremely well-written poem and believes that this poem will be the winner of the competition. This poem happens to be written by Elizabeth Johnson, a well-known poet in the US. But unfortunately, as a judge, *Julie is blind to the authors and therefore does not know it is Elizabeth Johnson who wrote this excellent poem*.
Condition 2: Referential (*de dicto* + *de re*) Julie is a judge in an ongoing poetry competition. She encounters an extremely well-written poem about the ocean and believes that this poem will be the winner of the competition. Julie remembers being told that Nicole, one of the best-known poets, submitted a poem about the ocean to the competition. *Therefore, Julie concludes that this poem must be written by Nicole and the first prize will be going to her. However, this poem was actually written by Elizabeth, a younger and lesser-known poet*. It is just a coincidence that the two poets wrote about the same topic.
Instruction According to this story, please indicate to what extent you agree or disagree with the following statements.
Target sentence Julie believes that **Elizabeth's poem** will win the competition. (**Referential *de re***) Highly Disagree ○ Somewhat Disagree ○ Uncertain ○ Somewhat Agree ○ Highly Agree ○

counterbalance and the randomization design were kept the same as those in Experiments 1 and 2.

4.2 Results

54 out of 60 participants (90%) contributed to the crucial analysis after the same screening procedure. Aligning with the prediction, Figure 4 shows that the bimodal distribution only appeared in the referential (*de dicto* + *de re*) condition; in the referential *de re* condition, the majority of the judgments accrued on the edge of agreement. This finding was also supported by Bayesian multilevel cumulative ordinal models. Here both the dummy coded condition (reference level = *de re* only) and the story (reference level = a) as well as their interaction were entered as the fixed effects; random intercepts and random slopes for the full fixed effects structure for the subject were entered as the random effect. The priors and all the meta parameters were set the same as in previous

experiments. All $\hat{R}$ for the sampling chains for all fixed effects were 1.0, indicating successful convergence. The result shows that overall the *de re* only condition elicited more agreement than the (*de dicto* + *de re*) condition (β = 1.21, HPD = [0.15, 2.71]).

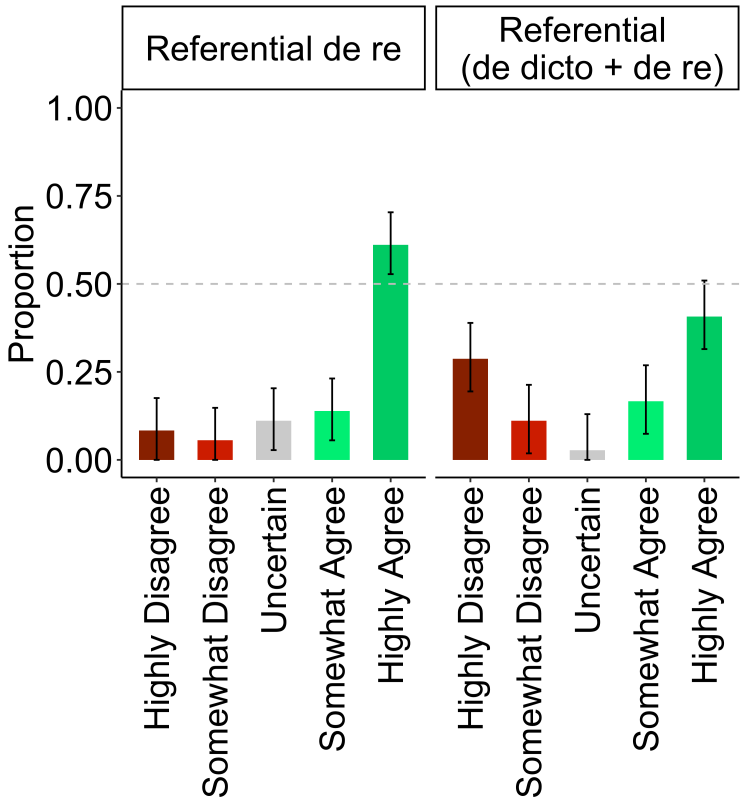

Figure 4: Proportion of different Likert scale choice of the referential *de re* reading in two contexts (The 95% CIs were output from the *MultinomialCI* package). The Referential *de re* context refers to the ignorance context. The Referential (*de dicto* + *de re*) context refers to the misapprehension context.

Figure 5 exhibits the by-story judgment pattern between the two conditions. We see clearly that within the context designed to support both the referential *de dicto* and referential *de re* reading, there are larger proportions of disagreement on the target sentence compared with the *de re* only condition. The statistical analysis shows that in story A and story C, under the (*de dicto*+*de re*) condition, there was marginally more disagreement than the *de re* only condition (story A: β = 1.06, HPD = [-0.11, 2.54]; story C: β = 1.29, HPD = [-0.19, 3.32]). In story B, there wasn't a significant difference between the two conditions (β = 0.22, HPD = [-1.79, 2.60]). In story D, there

was a statistical significance between the *de re* only ratings and the (*de dicto* + *de re*) ratings (β = 2.32, HPD = [0.58, 4.70]). The peculiarity of story B persisted here.

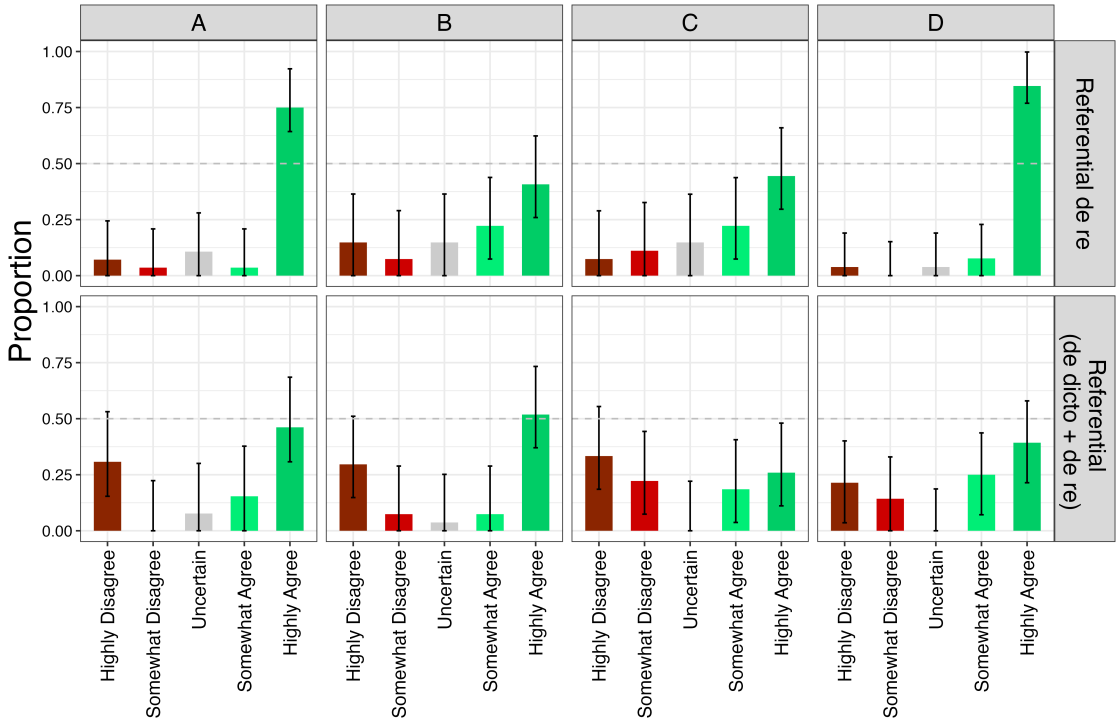

Figure 5: Acceptability ratings on the two conditions across four stories in Experiment Three.

Similar to Experiment 1, we also observe a difference in the percentage of participants choosing edge judgment labels between the two conditions. In the referential *de re* condition, 18 out of 54 participants (33%) chose "Highly Agree" twice and only 1 participant chose "Highly Disagree" twice. In the referential (*de re* + *de dicto*) condition, only 14 (26%) stayed with the "Highly Agree" option twice but 9 out of 54 participants (16.7%) went to "Highly Disagree" twice. This confirms that participants' judgment behavior changed between conditions.

4.3 Discussion

Experiment 3 further supports our hypothesis. The *de re* readings of definite noun phrases are acceptable in contexts that uniquely support a *de re* reading with an ignorance scenario. The acceptability of *de re* is affected in contexts which also permit a referential *de dicto* reading of

a competing noun phrase with a misapprehension scenario. The item-wise differences persist in this experiment, which further supports that the *de re* bimodal distribution arises in the face of this particular contextual manipulation.

Furthermore, there seem to be more disagreements on *de re* under the ignorance context in Experiment 3 than in Experiment 2 (Fig.4 vs. Fig.3).[12] We speculate that a priming effect (Bock, 1986) could play a role here: while participants chose "disagreement" for the *de re* interpretation in the misapprehension context (i.e. the referential (*de re*+*de dicto*) context in Fig.4), they were more tempted to do so with *de re* in the ignorance context (i.e. the referential *de re* context in Fig.4). Since the priming effect has been found not only in syntactic processing (e.g. Tooley & Traxler, 2010) but also in semantic and pragmatic reasoning (Bott & Chemla, 2016; Raffray & Pickering, 2010; Rees & Bott, 2018), it would be interesting to see whether and how the priming effect can be applied to the *de re*/*de dicto* context with further controlled study.

5. General discussion

One of the biggest challenges in modeling the meaning of a linguistic expression is to understand what aspects of meaning are stable across contexts and what aspects are context dependent. In this study, we applied an offline truth-value judgment task to investigate the contextual effect on the acceptability of *de re* reading of definite noun phrases, with the goal to understand semantic vs. pragmatic factors in *de re* interpretations. In Experiment 1, we replicated the bimodal distribution of the acceptability of *de re* readings in previous research. In Experiment 2, we found that by changing the context into the canonical *de re* permitting context, the *de re* readings did not suffer from degradation. Inspired by Sudo (2014) we labeled the contexts as "the ignorance context" and "the misapprehension context". We found that when the *de re* reading of a definite noun phrase was evaluated under the ignorance context – where the context only allowed one noun phrase to refer to the target object and the belief holder did not have that noun phrase in mind – the *de re* reading was almost always accepted; when the context featured a misapprehension scenario – where the

[12] We thank one reviewer for pointing this out.

belief holder wrongly associated a competing noun phrase with the object – the *de re* reading of the actual noun phrase in the belief report would receive a bimodal distribution of judgments. Altogether, these results suggest that the *de re* reading of definite noun phrases is generally available in English but that its acceptability is vulnerable to contextual effects, particularly the competition with a *de dicto* interpretation in cases of misapprehension.

Why might the misapprehension context elicit judgments in favor of the referential *de dicto* reading of the definite noun phrases and against the *de re* reading? We provide our tentative explanation by integrating the concept of pragmatic alternatives with the incremental processing mechanism in psycholinguistics.

We know that alternatives play a critical role in both assessing truth conditional semantics and in tightly related pragmatic processing, where the specific language and the larger pragmatic context constrain the alternatives that are considered. For example, if we consider the use of alternatives for definite descriptions in an anaphoric environment, we see that the language constrains possibilities for reference: some languages allow entirely covert noun phrases while others do not, some mark definite determiners while others have covert definite determiners, etc. For instance, to express the meaning "I bought a book$_i$. BOOK$_i$ was expensive.", the specific linguistic construct (e.g. definite noun phrases, pronouns) for BOOK that can be used anaphorically to refer to the book bought by me is determined by the available alternative referential nominal expressions in a language and the specific anaphoric constraints in that language's grammar (Ahn, 2020). In Mandarin, the position "BOOK$_i$" could be covert or bare noun which influences the relative prominence of other anaphoric expressions. But the lack of these two alternatives in English would render other anaphoric expressions like the definite noun phrase with an explicit definite article□ *the book*□ more prominent. Another example of linguistic constraints interacting with contextual factors is the well-studied case of processing scalar implicature. As shown by Degen and Tanenhaus (2016), the computation of scalar implicature (i.e. *some* is inferred as *not all*) is affected by the availability of context-specific alternatives. If numerical quantifiers *two* or *three* appeared as alternatives for *some* and *all* to describe the quantity of potential objects, the computation for scalar implicature

would be prolonged.

Following the alternative hypothesis, the misapprehension context in the case of *de re*/*de dicto* simultaneously provides two linguistic means of referring, one the *de dicto* noun phrase and the other the *de re* noun phrase, which automatically sets up these as competing alternatives.[13] During sentence comprehension, readers in the misapprehension context need to critically analyze their differences. The referential *de dicto* noun phrase is an appropriate referential expression only in the context of the belief holder's mind, not in the context of the broader story. The referential *de re* noun phrase is appropriate for reference in the broader context of the story, not in the context of the belief holder's mind.

When the participant reads the preamble of the critical statement from left to right, e.g. *Julie believes that ...*, in the poetry competition story, an incremental parser might anchor the mental representation of the sentence to the belief holder's mind and build a discourse model structure that expects further discussion relevant to what the belief holder believes to be true. The upcoming *Elizabeth's poem*, with a referential *de re* reading and evaluated to be true only in the broader context but not in the belief holder's mind, would require a revision in the reader's mental model and thus lead to degraded linguistic judgment. This might be analogous to discussions on the difficulty of getting the inverse scope reading for classic quantification scope sentences like *A boy climbed every tree* (Altmann & Steedman, 1988; Brasoveanu & Dotlačil, 2019; Fodor, 1982): when hearing the preamble *a boy climbed...*, listeners add a boy in the discourse model and that boy stands in the climbing relation with whatever would come up as the direct object. There, a surface scope reading ("there is a unique boy who climbed every tree") could arguably be more accessible than the inverse scope reading ("for every tree, there is a different boy who climbed it") because the subsequent *every tree* naturally and coherently builds up the original discourse model with one boy. On the other hand, the inverse scope reading requires the revision of the discourse model to multiple boys, which could result in an interpretation difficulty. Going back to the *de re*/*de dicto*

[13] The uniqueness of this case is that while the anaphoric referring expressions in Ahn (2020) and implicature reading of *some* in Degen and Tanenhaus (2016) deal with systematic competitions involving function words (e.g. determiners, demonstratives, quantifiers, numerals), the competition between a *de re* noun phrase versus a *de dicto* noun phrase is purely motivated by the selection of content words in the referential noun phrases.

story, the referential *de dicto* term *Nicole's poem* which is evaluated to be true in Julie's mental world is a natural follow-up of *Julie believes...*, compared to the referential *de re* term *Elizabeth's poem*. Along these lines, we hypothesize that it might take longer to process the *de re* sentence under the misapprehension context and future online measurements such as self-paced reading or eye-tracking could provide supporting evidence. To better understand how the word-by-word incremental processing mechanism plays a role in the interpretation of *de re*, it would be interesting to test variations of belief reports such as *Elizabeth's poem will win the competition, Julie believes* and cross-linguistic variations where the complement clause linearly precedes the matrix clause or the matrix verb. We predict that the *de re* reading would receive more disagreement as long as the linguistic constituents in that sentence are evaluated with respect to different contexts and the overall context features misapprehension, regardless of the linear order of these constituents.

A related, perhaps even more speculative, perspective to understand the interpretive process of this phenomenon comes from the false belief tasks in the Theory of Mind (ToM) literature (e.g. Apperly, 2012; Apperly & Robinson, 2003; Onishi & Baillargeon, 2005; Wimmer & Perner, 1983). We might expect ToM plays some role in resolving this ambiguity, and yet it makes essentially the opposite prediction to our findings. ToM generally suggests that accessing others' mental status is harder and costs extra cognitive resources (e.g. Gopnik, 1993; Wimmer & Perner, 1983), while here it is the referential *de dicto* (belief holder oriented) reading that is always accessible and it is the *de re* (speaker oriented) reading that had bimodal acceptability. It remains for future work to understand the role, if any, for ToM in this kind of task.

Furthermore, our research tackles the bimodal distribution of judgments of *de re* noun phrases in some contexts but leaves abundant room for exploration of the theory of *default de re* (Jaszczolt, 1997) and related relevant legal observations (J. C. Anderson, 2013). One tentative way to connect the three pieces discussed in Section 1.1 is that the broader scenario setting of *de re* interpretation might affect its accessibility. In the current experiments, the setting requires comprehenders to judge the acceptability of a *de re* reading of an ambiguous belief report given a specified context. On the other hand, in the settings of Jaszczolt (1997) and J. C. Anderson (2013), the involved

parties need to decide which interpretation out of the *de re*/*de dicto* ambiguities of a sentence is more salient, without an assumed context or even the knowledge of such ambiguity. This contrast is analogous to a contrast between (i) judging whether the sentence *Jack walked past the bank* is acceptable when describing a picture in which Jack walks past a financial institution (rather than the river bank) and (ii) providing the most salient interpretation of the sentence *Jack walked past the bank*. We show that the accessibility of the *de re* reading is subject to a well-controlled context but this does not mean that in any scenario, the *de re* reading is discouraged. In fact, during a rapid conversation or in a pressured environment, participants presumably bring a wealth of top-down cues about the most salient interpretation at hand to their interpretation in order to fulfill the higher-level goal in social interactions. With this, we suggest the adoption of more diverse research methodologies, for instance, a forced choice between the *de re* and *de dicto* interpretations or a paraphrasing task of ambiguous materials, to explore the salience of different ambiguous readings of belief reports under diverse settings.

Finally, this work is not without limitations. First, more work needs to be done to explain the item variance in Experiments 1 and 3 where some stories appear to receive more disagreement on the referential *de re* reading than others. Currently, one hypothesis concerns the information structure of the embedded clause: a passive structure with the *by* phrase could drive the interpretive focus to the predicate or the *by* phrase (Ambridge et al., 2016; Pullum, 2014) and cause the ignorance of the subtlety in the critical embedded subject, although this hypothesis requires a more well-controlled investigation to properly test. Similarly, individual differences between participants in *de re* disagreement are worth exploring. A valuable research question here is whether there is a natural way to demarcate groups of semantic comprehenders who might find both *de re* and *de dicto* equally available versus pragmatic comprehenders who are more sensitive to contextual factors for interpreting sentences and may prefer one reading. We might also find a fruitful division of individuals who retain openness to ambiguity versus individuals who find it difficult to switch interpretation once one is found. It could also be helpful to see whether other contextual factors (e.g. something other than a competing *de dicto* term which also highlights the belief holder's

mental status, as in Lewis et al. (2017)) can also affect the acceptability of *de re* readings. One potential direction is the Question under Discussion (e.g. Roberts, 2012; Ronai & Xiang, 2021): if the context makes the belief holder's mental activities the main topic of discussion, could the *de dicto* reading be even more prioritized than *de re*?

Overall, this study provides the first comprehensive experimental investigation into the acceptability of *de re*/*de dicto* readings of definite noun phrases and explores the effect of context on linguistic judgment. We hope this piece of work lays out the empirical foundation to study the referential properties of noun phrases in the intensional domain and enriches the set of linguistic phenomena that have increasingly attracted experimental methodological inspection (together with Jasbi, Bermudez, Zhang, et al., 2023; Jasbi et al., 2019; Tonhauser et al., 2018, a.o.). Our findings also extend the processing of scopes from the classic quantificational scope (C. Anderson, 2004; Brasoveanu & Dotlacil, 2015; Brasoveanu & Dotlačil, 2019; Tunstall, 1998) to the intensional domain. We hope to see more work along the line that discusses the relation between formal semantic representations of a language and the mental processes of the speaker/listener (Fodor, 1982). Furthermore, this study also sheds insight into the interdisciplinary interest of language and mind. Going beyond the developmental trajectory of ToM which has shown biases toward a speaker-oriented perspective (J. C. Anderson, 2013; Jaszczolt, 2010; Jaszczolt, 1997; Lewis et al., 2017; Wang et al., 2020), we show that contextual manipulations can guide readers toward a preference for making reference in terms of others' mental states over one's own.

Data accessibility statement

The experimental materials are in the Appendix. The raw data, graphs, and processing codes can be viewed and downloaded from the OSF platform via https://osf.io/6pvdz/.

Ethics and consent

All the human participants in the three experiments were recruited from online crowdsourcing platforms. The study has been approved by the Committee on the Use of Human Subjects (CUHS)

at Harvard University which serves as the Institutional Review Board (IRB17-0250: Online experimental semantics studies). Every participant in this study gave their consent before participating in the experiments and their data were anonymized.

Acknowledgment

We gratefully thank three thoughtful and careful reviewers for their generous feedback that significantly improved this paper, as well as Shannon Bryant, Gennaro Chierchia, Judith Degen, Masoud Jasbi, Joshua Martin, Jack Rabinovitch, Giuseppe Riccardi, Uli Sauerland, Jesse Snedeker, and Julia Sturm for many helpful comments and insights along the way, and appreciate broader discussions with our audiences at the Harvard Meaning & Modality Lab, Harvard LangCog Workshop, Language Acquisition Lab at Tsinghua University, Experiments in Linguistic Meaning 2020, and Chicago Linguistics Society 2022. Y.Z. and K.D. acknowledge research funding from the Institute of Quantitative Social Sciences at Harvard University.

Competing interests

The authors have no competing interests to declare.

Authors' contributions

Both authors contributed to every aspect of the study, including but not limited to conceptualization of the study, experimentation with data curation and formal analysis, funding acquisition, and manuscript creation and revision. Y.Z. made the visualizations. K.D. supervised the overall study.

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A. Materials in Experiment one

Table 4: Complete material for Exp.1 .

Story A
Referential *De Dicto* + Referential *De Re*
Julie is one of the judges of an ongoing poetry competition. The best poem that she has read so far is an extremely intriguing poem about the ocean. She believes that this poem will win the competition. Julie remembers being told that Nicole, one of the best-known poets, submitted a poem about the ocean to the competition. Therefore, Julie concludes that this poem must be written by Nicole and the first prize will be going to her. However, this poem was actually written by Elizabeth, a younger and lesser-known poet. It is just a coincidence that the two poets wrote about the same topic.
According to this story, please indicate to what extent you agree or disagree with the following four statements.
[S1 Target] Julie believes that Nicole's poem will win the competition. (Referential *de dicto* reading)
[S1 Target] Julie believes that Elizabeth's poem will win the competition. (Referential *de re* reading)
[S2 True] Elizabeth is a young poet.
[S3 False] Elizabeth and Nicole met each other and decided that they will both write poems about the ocean.
[S4 Unsure] Julie will also be the judge for the poetry competition next year.
Story B
Referential *De Dicto* + Referential *De Re*
Mr. and Mrs. Johnson have two high school girls, Annie and Grace. One day, Mrs. Johnson finds a wrapped present lying on the front porch of their house. A note on the box says: "From your secret admirer". Mrs. Johnson remembers that one day she saw Annie's classmate Mike standing in front of their house for a long time without knocking at the door. She also remembers being told that Annie is very popular in her class, so she concludes that Mike sent the gift to Annie. It turns out that Mike did send the gift, but to Grace. Grace and Mike met each other in a book club, and Mike has admired Grace since then.
According to this story, please indicate to what extent you agree or disagree with the following four statements.

[S1 Target] Mrs. Johnson believes that Annie's gift was sent by Mike. (Referential *de dicto* condition)

[S1 Target] Mrs. Johnson believes that Grace's gift was sent by Mike. (Referential *de re* condition)

[S2 True] Annie is the youngest daughter of Mrs. Jackson.

[S3 False] Grace and Mike knew each other from jazz band.

[S4 Unsure] The gift was wrapped in pink paper.

Story C

Referential *De Dicto* + Referential *De Re*

Susan works at a hospital. She is responsible for checking in visitors whose relatives and friends are in the maternity ward. One day, a man comes to Susan and asks to visit Haley. His surname is the same as Haley's and they both have beautiful blond hair. Susan remembers Haley saying that she has a brother, so Susan concludes that this man is Haley's brother. Since Haley will deliver the little baby soon, Susan also thinks that the man will accompany Haley for a while. Yet, it turns out that this man is not Haley's brother but instead, Haley's husband. Haley took her husband's surname, and they both have blond hair.

According to this story, please indicate to what extent you agree or disagree with the following four statements.

[S1 Target] Susan believes that Haley's brother will accompany her for a while. (Referential *de dicto* condition)

[S1 Target] Susan believes that Haley's husband will accompany her for a while. (Referential *de re* condition)

[S2 True] Haley is receiving medical care in the maternity ward.

[S3 False] Susan thinks the man is related to Haley because of his brown hair.

[S4 Unsure] The man is bringing a bouquet of daisies to Haley.

Story D

Referential *De Dicto* + Referential *De Re*

Alice and Tracy live in the same apartment and always help each other with daily errands. One day, Tracy is gathering up their laundry and she finds an apron with a large coffee stain lying on the sofa. Tracy remembers Alice saying that she usually wears her favorite apron when she cooks and the other day she spilled a cup of coffee while cooking. Tracy thus concludes that what she found is Alice's favorite apron and it needs to be washed. As a matter of fact, however, what Tracy found is Alice's spare apron, not her favorite one. Alice's favorite apron was already in the laundry at the time when she spilled the coffee onto her spare apron.
According to this story, please indicate to what extent you agree or disagree with the following four statements.
[S1 Target] Tracy believes that Alice's favorite apron needs to be washed. (Referential *de dicto* condition) **[S1 Target]** Tracy believes that Alice's spare apron needs to be washed. (Referential *de re* condition) **[S2 True]** Alice usually wears an apron when she cooks. **[S3 False]** The apron with a large coffee stain was lying on the table when Tracy discovered it. **[S4 Unsure]** Tracy altogether gathered three pounds of laundry.

B. Materials in Experiment two

Table 5: Complete material for Exp.2 .

Story A	
Attributive *De Dicto*	**Referential *De Re***
Julie is a judge of an ongoing poetry competition. She is told that Elizabeth Johnson, one of the best-known poets in the US, also submitted a poem to the competition. Julie is a huge fan of Elizabeth. Even though Julie is blind to the authors and does not know which poem is written by Elizabeth, she believes that no matter which poem Elizabeth submitted, it will win the competition.	Julie is a judge of an ongoing poetry competition. She encounters an extremely well-written poem and believes that this poem will be the winner of the competition. This poem happens to be written by Elizabeth Johnson, a well-known poet in the US. But unfortunately, as a judge, Julie is blind to the authors and therefore does not know it is Elizabeth Johnson who wrote this excellent poem.

According to this story, please indicate to what extent you agree or disagree with the following four statements.
[S1 Target] Julie believes that Elizabeth's poem will win the competition.
[S2 True] Elizabeth Johnson is a well-known poet in the US.
[S3 False] Julie knows exactly who submitted which poem for the competition.
[S4 Unsure] Julie will also be the judge for the poetry competition next year.

Story B	
Attributive *De Dicto*	**Referential *De Re***
Mr. and Mrs. Jackson always play the gift exchange game on Christmas eve. In the game, the two of them and each of their five kids prepare a gift. Not knowing who prepares which gift, they take turns to select an anonymous gift and, in this way, get their Christmas gift from their family member. Despite this rule, Mrs. Jackson knows that the youngest daughter Annie always secretly asks the eldest brother David for his gift and then selects his. Mrs. Jackson believes that this year is no exception, even though she does not know which gift is prepared by David.	Mr. and Mrs. Jackson always play the gift exchange game on Christmas eve. In the game, the two of them and each of their five kids prepare a gift. Not knowing who prepares which gift, they take turns selecting an anonymous gift and, in this way, get their Christmas gift from their family. Mrs. Jackson encounters a very beautifully wrapped gift and believes that it will be selected by Annie who always chooses the gift based on how beautiful the wrapping is. Unbeknown to Mrs. Jackson, this gift was prepared by David.
According to this story, please indicate to what extent you agree or disagree with the following four statements.	
[S1 Target] Mrs. Jackson believes that David's gift will be selected by Annie this year.	
[S2 True] Annie is the youngest daughter of Mrs. Jackson. (Attributive *de dicto* condition)	
[S2 True] Annie is the youngest daughter of Mrs. Jackson. (Referential *de re* condition)	
[S3 False] Mr. and Mrs. Jackson only have two kids.	
[S4 Unsure] All of the gifts will be wrapped in pink paper.(Attributive *de dicto* condition)	
[S4 Unsure] The gift encountered by Mrs. Jackson is wrapped in pink paper. (Referential *de re* condition)	

Story C	
Attributive *De Dicto*	**Referential *De Re***

Susan works at a hospital. She is taking care of Haley who will deliver a little baby soon. Susan has not seen Haley's husband and does not know who he is yet. But she constantly hears Haley talking to her baby "Daddy will be here and will be with mummy for a few days", which makes Susan believe that her husband will keep her company for a while.	Susan works at a hospital. She is responsible for checking in visitors whose relatives and friends are in the maternity ward. One day, a man comes to Susan and asks to visit Haley. Since Haley will deliver a little baby soon, Susan thinks that the man will keep Haley's company for a while. Yet Susan fails to ask who the man is because he immediately goes to Haley's room upon knowing her room number. Luckily, the man is just Haley's husband, not someone irrelevant or someone who bears ill will.
According to this story, please indicate to what extent you agree or disagree with the following four statements.	
[S1 Target] Susan believes that Haley's husband will keep her company for a while.	
[S2 True] Haley is receiving medical care in the maternity ward.	
[S3 False] Haley has just delivered a baby. (Attributive *de dicto* condition)	
[S3 False] Susan is a surgeon. (Referential *de re* condition)	
[S4 Unsure] Haley's mom will also visit Haley. (Attributive *de dicto* condition)	
[S4 Unsure] The man is bringing a bouquet of daisies to Haley. (Referential *de re* condition)	

Story D	
Attributive *De Dicto*	**Referential *De Re***
Alice and Tracy live in the same apartment and often help each other with daily errands. Alice is a dancer and always wears different beautiful dresses for work. One day, Tracy is gathering their laundry. Before she throws the dirty clothes to the washing machine, she realizes Alice will be home soon and will want to wash what she is wearing after sweating a lot while dancing. Therefore, she pauses the laundry work and waits for Alice to return home.	Alice, Lily, and Tracy live in the same apartment and often help each other with their daily errands. One day, Tracy is gathering up their laundry and finds a dirty dress on the sofa. She thinks that the dress needs to be washed and throws it into the washing machine, even though she doesn't know whose dress it is. It turns out that, unbeknown to Tracy, this dress belongs to Alice and Alice requires it to be washed by hand.
According to this story, please indicate to what extent you agree or disagree with the following four statements.	
[S1 Target] Tracy believes that Alice's dress needs to be washed.	

[S2 True] Alice works as a dancer. (Attributive *de dicto* condition)
[S2 True] The dirty dress is lying on the sofa. (Referential *de re* condition)
[S3 False] Alice, Lily and Tracy never help each other with their daily errands.
[S4 Unsure] Alice's favorite dress is violet. (Attributive *de dicto* condition)
[S4 Unsure] Tracy altogether gathered three pounds of laundry. (Referential *de re* condition)

C. Materials in Experiment three

Table 6: Complete material for Exp.3 .

Story A	
De Re* + *De Dicto	***De Re* only**
Julie is a judge of an ongoing poetry competition. She encounters an extremely well-written poem about the ocean and believes that this poem will be the winner of the competition. Julie remembers being told that Nicole, one of the best-known poets, submitted a poem about the ocean to the competition. Therefore, Julie concludes that this poem must be written by Nicole and the first prize will be going to her. However, this poem was actually written by Elizabeth, a younger and lesser-known poet. It is just a coincidence that the two poets wrote about the same topic.	Julie is a judge of an ongoing poetry competition. She encounters an extremely well-written poem and believes that this poem will be the winner of the competition. This poem happens to be written by Elizabeth Johnson, a well-known poet in the US. But unfortunately, as a judge, Julie is blind to the authors and therefore does not know it is Elizabeth Johnson who wrote this excellent poem.
According to this story, please indicate to what extent you agree or disagree with the following four statements.	
[S1 Target] Julie believes that Elizabeth's poem will win the competition.	
[S2 True] Julie encounters a very good poem submitted to the competition.	
[S3 False] Julie knows exactly who submitted which poem for the competition.	

[S4 Unsure] Julie will also be the judge for the poetry competition next year.

Story B	
De Re* + *De Dicto	***De Re* only**
Mr. and Mrs. Jackson always play the gift exchange game on Christmas eve. In the game, the two of them and each of their five kids prepare a gift. Not knowing who prepares which gift, they take turns selecting an anonymous gift and, in this way, get their Christmas gift from their family. Mrs. Jackson encounters a very beautifully wrapped gift and believes that it will be selected by Annie who always chooses the gift based on how beautiful the wrapping is. She also believes that this gift was prepared by Jane because Jane's gift is usually beautifully wrapped. However, what Mrs. Jackson doesn't know is that this gift was in fact prepared by David, not Jane. It is just a coincidence that this year Jane's and David's gifts were both beautifully wrapped.	Mr. and Mrs. Jackson always play the gift exchange game on Christmas eve. In the game, the two of them and each of their five kids prepare a gift. Not knowing who prepares which gift, they take turns selecting an anonymous gift and, in this way, get their Christmas gift from their family. Mrs. Jackson encounters a very beautifully wrapped gift and believes that it will be selected by Annie who always chooses the gift based on how beautiful the wrapping is. Unbeknownst to Mrs. Jackson, this gift was prepared by David.
According to this story, please indicate to what extent you agree or disagree with the following four statements.	
[S1 Target] Mrs. Jackson believes that David's gift will be selected by Annie this year. **[S2 True]** The gift prepared by David is very beautiful. **[S3 False]** Mr. and Mrs. Jackson only have two kids. **[S4 Unsure]** The gift encountered by Mrs. Jackson is wrapped in pink paper.	

Story C	
De Re* + *De Dicto	***De Re* only**

Susan works at a hospital. She is responsible for checking in visitors whose relatives and friends are in the maternity ward. One day, a man comes to Susan and asks to visit Haley. His surname is the same as Haley's and they both have beautiful blond hair. Susan remembers Haley saying that she has a brother, so Susan concludes that this man is Haley's brother. Since Haley will deliver the little baby soon, Susan also thinks that the man will keep Haley's company for a while. Yet, it turns out that this man is not Haley's brother but instead, Haley's husband. Haley took her husband's surname, and they both have blond hair.	Susan works at a hospital. She is responsible for checking in visitors whose relatives and friends are in the maternity ward. One day, a man comes to Susan and asks to visit Haley. Since Haley will deliver a little baby soon, Susan thinks that the man will keep Haley's company for a while. Yet Susan fails to ask and thus doesn't know who the man is. He immediately goes to Haley's room upon knowing her room number. Luckily, the man is just Haley's husband, not someone irrelevant or someone who bears ill will.
According to this story, please indicate to what extent you agree or disagree with the following four statements.	
[S1 Target] Susan believes that Haley's husband will keep her company for a while. **[S2 True]** Haley is receiving medical care in the maternity ward. **[S3 False]** Susan works as a surgeon at the hospital. **[S4 Unsure]** The man is bringing a bouquet of daisies to Haley.	

Story D	
De Re* + *De Dicto	***De Re* only**
Alice, Lily, and Tracy live in the same apartment and often help each other with their daily errands. One day, Tracy is gathering up their laundry and finds a dirty dress on the sofa. Based on the observation that Lily always throws dirty clothes on the sofa, Tracey thinks that the dress belongs to Lily. Tracey also believes that it needs to be washed and thus throws it into the washing machine. It turns out that this dress actually belongs to Alice, not Lily. Furthermore, Alice always requires her dress to be washed by hand. She will be mad after knowing what happens to her dress.	Alice, Lily, and Tracy live in the same apartment and often help each other with their daily errands. One day, Tracy is gathering up their laundry and finds a dirty dress on the sofa. She thinks that the dress needs to be washed and throws it into the washing machine, even though she doesn't know whose dress it is. It turns out that, unbeknown to Tracy, this dress belongs to Alice and Alice requires it to be washed by hand.

According to this story, please indicate to what extent you agree or disagree with the following four statements.
[S1 Target] Tracy believes that Alice's dress needs to be washed.
[S2 True] The dirty dress is lying on the sofa.
[S3 False] Alice, Lily and Tracy never help each other with their daily errands.
[S4 Unsure] Tracy altogether gathered three pounds of laundry.