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Partial plurality inferences of plural pronouns and dynamic pragmatic enrichment*

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Abstract I explore the semantics/pragmatics of plural pronouns by discussing the *partial plurality inference* that arises under *quantificational subordination*. I propose an anti-presupposition account coupled with Sudo's (2023) *dynamic implicature* approach to plurality inferences based on *plural information states*, i.e. sets of variable assignments (van den Berg 1996). I further discuss the implications of the proposed analysis to the locality of anti-presupposition calculation and difference between animate instances and inanimate instances of plural pronouns in English.

Keywords: plurality, anaphora, quantificational subordination, partial plurality inferences, dependent pronouns, presupposition, Maximise Presupposition!, animacy, dynamic plural logic

1 Introduction

This paper discusses the interaction of two phenomena. One is *partial plurality inferences* (Sauerland 2003; Sauerland, Anderssen & Yatsushiro 2005; Spector 2007; Sauerland et al. 2005; Ivlieva 2014, 2020; Križ 2017; Sudo 2023: a.o.). When a bare plural occurs under the scope of a quantifier, it does not require its value to be plural with respect to every member of the witness set. Instead, it just requires the value of the bare plural to be plural with respect to at least one of the witnesses. They come in two types as exemplified in (1a) and (1b).

(1) a. Exactly one of these coats has **pockets**.
b. Every passenger of this flight lost their **suitcases**. (Sudo 2023)

(1a) is true iff exactly one coat has multiple pockets and other coats do not have any pocket.[1] Similarly, (1b) presupposes that every passenger has at least one suitcases and at least one passenger have multiple suitcases.

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1 Sudo (2023) notes that (1a) may have another reading with a non-partial plurality inference, but what is of interest is the availability of the reading with a partial inference. This generally applies to examples with partial plurality inferences.

The other phenomenon is *quantificational subordination* (Karttunen 1969; van den Berg 1996; Nouwen 2007: a.o.). It has been observed that singular anaphora across quantifier scope is not possible as exemplified in (2). Following the convention, the superscript ^{u_n} stands for the first mention of a referent u_n and the subscript $_{u_n}$ stands for the anaphoric link to a referent u_n.

(2) **Every** student^{u_1} wrote a manuscript^{u_2}. #It$_{u_2}$ is well written.

However, such anaphora becomes possible if the singular pronoun is also under the scope of another quantifier as exemplified in (3). This is an instance of quantificational subordination.

(3) a. Every student^{u_1} wrote a manuscript^{u_2}.
b. They$_{u_1}$ **each** submitted it$_{u_2}$ to a journal.

Now, I show what happens when one combines them. (4) shows a vanilla quantificational subordination, which serves as a baseline for my discussion below. Here, none of the PhD student corresponds to multiple papers. In this context, the singular pronoun "it" is favoured to pick up a singular paper relative to each PhD student.

(4) Scenario: There are ten PhD students in this department. This semester, every student wrote exactly one paper. They all submitted their papers to a journal.
a. Every PhD student^{u_1} wrote a paper^{u_2} in this semester.
b. They$_{u_1}$ each submitted $\{$it / %them$\}_{u_2}$ to a journal.

On this point, note that some speakers can use the plural pronoun "them" in this context, which is also reported in Nouwen (2003): subordination with a plural pronoun has a (contextually strange) reading (5b-i), but some speakers can get the reading (5b-ii) as well.

(5) a. Every student^{u_1} wrote a manuscript^{u_2}.
b. They$_{u_1}$ submitted them$_{u_2}$ to a journal.
i. Each student submitted all the manuscripts written themselves.
ii. % Each student x submitted the paper x wrote.

Now, (6) is the target condition, which shows the interaction between partial plurality inferences and quantificational subordination. This scenario is compatible with a partial plurality inference, but not with non-partial plurality inference: three students wrote multiple papers, but the rest wrote exactly one paper.[2] Here, the singular pronoun "it" becomes infelicitous while the plural pronoun "them" is available.

2 While Spector (2007); Zweig (2009); Križ (2017) report that partial plurality inferences are also observed under the scope of a distributive universal quantifier, Sudo (2023) makes a warning that it is less clear as such sentences also have a prominent reading with non-partial plurality inference.

(6) Scenario: There are ten PhD students in this department. This semester, seven of them wrote exactly one paper, while the other three students wrote more than one paper. They all submitted their papers to a journal.

a. Every PhD student^{u_1} wrote (some) papers^{u_2} in this semester.

b. They$_{u_1}$ each submitted {*it / them}$_{u_2}$ to a journal.

Crucially, a speaker who accepts both "it" and "them" in (4) rejects "it" in (6), and speakers who reject "them" in (4) accept it in (6). Thus, the partial plurality inference with respect to pronoun number is observed independently of the individual variation in (5).[3] This suggests that the plurality requirement for the antecedent of "them" should not be hard-wired to its lexical semantics. This provide a new piece of support for what Sauerland (2003); Sauerland et al. (2005) suggest for plural pronouns. A singular pronoun presupposes that its antecedent has an atomic value and a plural pronoun *anti-presupposes* that its antecedent has a non-atomic value due to pragmatic competition.[4]

In the rest of this paper, I provide an implementation of an anti-presupposition approach to plural pronouns that derives the observed partial plurality inferences under quantificational subordination. I further discuss two consequences of this approach. First, presuppositional competition for a plural pronoun has to be checked optionally globally in cases of quantificational subordination, but it has to be checked locally in cases of in-scope binding. Second, animate intra-sentential dependent plural pronouns may have to be analysed as an instance of singular "they."

2 Theoretical Background

This section introduces the theoretical background for this paper. I adopt *Dynamic Plural Logic (DPlL)* (van den Berg 1996: *et seq*) to derive the partial plurality anti-presupposition. For this, I start with illustration of the classical dynamic theory.[5] Readers who are already familiar with it may skip this section.

3 The full assessment of this independence calls for an experimental investigation, though.

4 Note that Sauerland (2003); Sauerland et al. (2005) claim that plurality inferences of plural indefinites are also anti-presuppositions, but I do not commit to this. See Spector (2007) for an argument against an anti-presupposition approach to bare plurals.

5 The partial plurality inference might potentially pose a puzzle for the situation-driven E-type approach. Roughly speaking, "them" in (6) is an elided version of "the papers" in an E-type approach and its value is the unique collection of papers in each *minimal situation* (or *exemplifying situation*) in which a PhD student x submitted it. However, if "the papers" has a strictly plural denotation, each minimal situation contains a non-atomic individual and thus only a total plurality inference arises. On the other hand, if "the papers" has a number-neutral denotation, each minimal situation contains an atomic individual: a situation that contains more than one paper is not minimal. Thus, it cannot derive a plurality inference at all. This poses a challenge for an approach with minimal situations. I thank to Yusuke Yagi (p.c.) for pointing it out. I leave the precise examination of it for future research.

2.1 Dynamic Predicate Logic

Theories under the umbrella of Dynamic Semantics are designed so that the meaning of a sentence expresses an update of the discourse context.[6] In this paper, I adopt notations in the style of *Dynamic Predicate Logic (DPL)* (Groenendijk & Stokhof 1991). An *information state* stores the information of which referents have been introduced to the conversational discourse. I model an information state g with a variable assignment.[7,8] A DPL formula denotes a relation between information states, i.e. g is updated to h with ϕ.[9] I take an ordinary first-order model $M = \langle D, I \rangle$, which is a pair of a non-empty set of entities D and an interpretation function I. The denotation function $[\![\ ]\!]$ maps a formula to a relation between information states. The notation $g[\![\phi]\!]h$ means that ϕ takes g as its input and h as its output. Truth is defined relative to a pair of information states.

(7) **Truth in DPL**: a formula ϕ is true with respect to an information state g iff there is an information state h such that $g[\![\phi]\!]h$.

A pronoun denotes a free occurrence of variable and its value is assigned by the current information state. Following the tradition from Karttunen (1969), I call the variables in the domain of variable assignments *discourse referents* (dref). I use letters u_1, u_2, u_3 ... for drefs and a, b, c for individual constants.[10] Discourse update often extends input information states so that they assign a new value to a

6 I do not have a particular commitment for using the term "sentence" instead of "utterance." Since I do not discuss the contribution of illocutionary force nor discourse update relative to conversational participants, the difference between these terms does not matter in this paper.

7 One may alternatively define an information state as pairs of a possible world and a variable assignment. Later in this paper, I call such a set of world-assignment pairs a *possibility*.

8 Usually, a variable assignment is defined as a set of variable-value pairs. However, one can also define information states as primitives and postulate axioms to ensure that they behave exactly like variable assignments (Muskens 1996). The latter option makes it easy to implement sub-clausally compositional version of dynamic theories. As a full compositional implementation goes beyond the scope of this paper, I adopt the former option. However, the proposed analysis is compatible with the latter option and a fully compositional version of my analysis is more desirable to consider the interaction of presupposition resolution and distributivity.

9 Here lies a theoretical choice. An alternative is to assume that (i) a context is a set of information states and (ii) a formula denotes a **function** from an input context to an output context. Sudo (2023) adopts this option: he defines a possibility as a set of pairs of a possible world and a (set of) variable assignment(s). Both options work the same in most cases, i.e. a formula is evaluated in a point-wise fashion with respect to each input-output pair. However, see Charlow (2017) for an argument that functional updates works better than relational updates to capture the cumulative readings of non-increasing modified numerals, but making an update fully functional over-generates. This matter is orthogonal to the main point of this presentation.

10 If one takes drefs as primitive entities other than individuals, u_1, u_2, u_3 can be defined as **constants** of drefs. For example, Muskens (1996) adopts *registers* of type π and drefs are constants of type π.

dref. I call this process *discourse referent introduction* and it is expressed as random (re)assignment of the value of a dref. I notate it as $g[u_n]h$ and it is defined in (8): g and h minimally differ with respect to the newly introduced dref u_n.[11]

(8) $g[u_n]h \Leftrightarrow \forall u[u \neq u_n \rightarrow g(u) = h(u)]$

Now, dynamic existential quantification is defined as (9). It extends an input g with a pair of a dref u and its new value.

(9) $[\![\exists u]\!] = \{\langle g, h\rangle : g[u]h\}$

Dynamic conjunction is defined as relational composition as shown in (10). I notate it with the sequencing operator ';' to avoid over-loading '&'.

(10) $g[\![\phi;\psi]\!]h = \{\langle g, h\rangle | \exists k[g[\![\phi]\!]k \,\&\, k[\![\psi]\!]h]\}$

A sequence of sentences ϕ and ψ is translated to $\phi;\psi$. Some formulae check if output variable assignments satisfy some conditions and discard those which do not meet the conditions. Such formulae are called *tests*, e.g., lexical relations. For notational brevity, I use $\mathrm{R}(h(u))$ as an abbreviation of $h(u) \in I(\mathrm{R})$.

(11) $[\![\mathrm{R}(u_1)...(u_n)]\!] = \{\langle g, h\rangle | g = h \,\&\, \langle h(u_1), ..., h(u_n)\rangle \in I(\mathrm{R})\}$

As a simple illustration, consider (12a) and (12b).

(12) a. A girl^{u_1} entered. b. She$_{u_1}$ looks tired.

Their denotations are respectively given in (13a) and (13b).

(13) a. $\{\langle g, h| \exists k[g[u_1]k \,\&\, k = h \,\&\, \mathrm{girl}(h(u_1)) \,\&\, \mathrm{entered}(h(u_1))]\}$
b. $\{\langle h, j| \exists i[h[u_2]i \,\&\, i = j \,\&\, \text{look tired}(j(u_2))\}$

(12a) is dynamically true iff an input information state g can be extended to h with a new value on u_1 such that $h(u_1)$ is a girl who entered. (13b) takes the output h of (13a) as its input and tests if the value of h_2 looks tired in $j = h$. If j does not pass this test, this is excluded. Crucially, "she" picks up the value of u_1 under variable assignments h, which is an extensions of g with a new value introduced by "a girl."

11 In this paper, I work with total assignments, but one may recast the same analysis with partial assignments.

2.2 Dynamic semantics with plurals

This section introduces *Dynamic Plural Logic* (van den Berg 1996), a dynamic logic with plurals. For this, let me start with the anaphoric potential of singular indefinites under the scope of universal quantifiers. The classical dynamic theories define universal quantification as a test as defined in (14).

(14) $g[\![\forall u\, \phi]\!]h = \{\langle g,h| g = h \,\&\, \forall i[h[u]i \rightarrow \exists j[i[\![\phi]\!]j]]\}$

Thus, universal quantifiers are expected to behave as an inherent barrier for anaphora. At the first sight, this makes the right prediction.

(15) a. Every student^{u_1} wrote a manuscript^{u_2}.
b. *She$_{u_1}$ submitted it$_{u_2}$ to a journal.

However, quantificational subordination poses a challenge to this. The relevant example is repeated below.

(3) a. Every student^{u_1} wrote a manuscript^{u_2}.
b. They$_{u_1}$ **each** submitted it$_{u_2}$ to a journal.

DPlL offers a solution to this puzzle by explicitly incorporating plurals in its architecture. I adopt the set-theoretical interpretation of the classical analysis of plurals (Link 1983: *et seq*). Sum-formation '+' takes two individuals and returns the union of them. If an individual is a singleton set, it is *atomic* and it is non-atomic otherwise. The part-of relation '⊆' partially orders individuals, i.e. x is part of y iff $x \subseteq y$. For notational brevity, I omit { } when I refer to individuals.

(16) $a \subseteq a+b$ and $b \subseteq a+b$

(17) $[\![\text{atom}(x)]\!] \Leftrightarrow \forall y[y \subseteq x \rightarrow y = x]$

DPlL introduces the notion of *plurality of variable assignments*, a set of variable assignments (van den Berg 1996; Nouwen 2003; Brasoveanu 2007, 2008: a.o.). Accordingly, a DPlL context is modeled as a *plural information state*, a set of variable assignments. To obtain non-atomic individuals, one has to sum up the singular values of a dref under the members of a set of variable assignments.[12] i.e. $G(u) = \{g(u)| g \in G\}$. DPlL explicitly stores and retrieves *quantificational dependencies*, which are defined in (18b): u_m is dependent on u_n if they *co-vary*.

12 This is not a consensus among varieties of DPlL. van den Berg (1996); Nouwen (2003); Kuhn (2017) assume that the domain of a variable assignment consists of atomic individuals, but Brasoveanu (2008); Henderson (2014); Law (2020) assume that the domain of a variable assignment consists of atomic individuals and non-atomic individuals, i.e. it is *closed under sum*. This difference does not matter for the main point of this presentation.

(18) a. $G_{u_n=d} = \{g : g \in G \,\&\, g(u_n) = d\}$

b. In a plural information state G, u_m is dependent on u_n iff $\exists d, e \in G(u_n)\,[G_{u_n=d}(u_m) \neq G_{u_n=e}(u_m)]$ (van den Berg 1996)

Dref introduction is generalised for plural information states as defined in (19) (Brasoveanu 2008, 2010; Henderson 2014; Kuhn 2015) .[13]

(19) $G[u]H \Leftrightarrow \forall g \in G\, \exists h \in H\, [g[u]h] \,\&\, \forall h \in H\, \exists g \in G\, [g[u]h]]$

Evaluation of lexical relations can be collective or distributive.[14]

(20) a. $[\![\mathrm{R}(u_1)...(u_n)]\!] = \{\langle G, H\rangle : G = H \,\&\, \forall h \in H\, [\langle h(u_1), ..., h(u_n)\rangle \in I(\mathrm{R})]\}$ (distributive)

b. $[\![\mathrm{R}(\cup u_1)...(\cup u_n)]\!] = \{\langle G, H\rangle : G = H \,\&\, \langle H(u_1), ..., H(u_n)\rangle \in I(\mathrm{R})]\}$ (collective)

Atomicity conditions are defined as collective conditions.

(21) $[\![\mathrm{Atom}(u)]\!] = \{\langle G, H\rangle | G = H \,\&\, \mathrm{atom}(H(u))\}$

Finally, the dynamic distributivity operator δ (van den Berg 1996: *et seq*) introduces new dependencies to the discourse.

(22) $[\![\delta_{u_n}(\phi)]\!] = \{\langle G, H\rangle | G(u_n) = H(u_n) \,\&\, \forall d\, [d \in G(u_n) \to G_{u_n=d}[\![\phi]\!]H_{u_n=d})]\}$

Now, δ allows one to define an *externally-dynamic* universal quantifier: the values introduced under δ are passed on to the output plural information state. Since the sum of those values is plural, a singular pronoun cannot pick them up when they are not under the scope of another δ. Thus, (15b) is still predicted to be infelicitous. However, if a singular pronoun is under the scope of another δ, it is evaluated with respect to subsets of H and its use is felicitous if its value is atomic in each of those subsets.[15] Thus, (3b) is predicted to be felicitous.

13 The varieties of DPlL agree that distributive quantification introduces new dependencies, but disagree if introduction of new plural values can also introduce new dependencies. (19) allows a new dref to be dependent to old dref. However, (i) makes a new dref independent from old drefs (van den Berg 1996; Nouwen 2003; Law 2020). This difference is orthogonal to the main point of this paper.

i. $G[u]H \Leftrightarrow \exists D\, [H = \{h | \exists g\, \exists d\, [g[u]h \,\&\, \mathrm{v}(u)(h) = d \,\&\, g \in G \,\&\, d \in D]\}]$

14 Again, varieties of DPlL differ in this respect. The original DPlL in van den Berg (1996) and the versions in Nouwen (2003); Law (2020) only adopts (20b), while Brasoveanu (2008); Dotlačil (2013); Henderson (2014); Kuhn (2017) adopts both or use (20a) as the default option. For my purpose, (20a) is necessary. The atomicity condition has to be collectively evaluated, but it does not necessarily require (20b) because the atomicity condition can be defined independently of lexical relations. This choice does not matter for my purpose, though.

15 This is the reason why the atomicity condition has to be defined as a collective condition.

3 Pragmatic enrichment in Dynamic Plural Logic

In this section, I discuss Sudo (2023), who derives partial plurality inferences as *dynamic global implicatures* based on plural information states. My contribution is just an addition of *dynamic anti-presupposition* to it.

3.1 Dynamic scalar implicature

Sudo (2023) points out that the Gricean tradition and the dynamic tradition developed independently and their expected interaction has not been fully explored. On the Gricean side, an utterance triggers an implicature if there is *more informative* alternatives. On the dynamic side, an utterance conveys not only truth-conditional information, but also *anaphoric information*. If an utterance conveys anaphoric information, then the Gricean consideration should also apply to this type of information. Given the distinction between truth-conditional information and anaphoric information, he argues that a singular indefinite is **truth-conditionally not more informative**, but **anaphorically more informative** than a bare plural. He models truth-conditional information with a set of possible worlds and anaphoric information with a set of plural information states. For illustration, I define a *possibility* as a pair of a world and a plural information state $\langle w,G\rangle$ and a formula denotes a relation between possibilities.[16] The definition of truth is refined, accordingly.

(23) **DPlL truth with possibilities**: ϕ is true with respect to an input possibility $\langle w,G\rangle$ iff there is an output possibility $\langle w',H\rangle$ such that $\langle w,G\rangle[\![\phi]\!]\langle w',H\rangle$.

This change does not essentially affect the content of dref introduction.

(24) $\langle w,G\rangle[u]\langle w,H\rangle \Leftrightarrow \forall g\in G\,\exists h\in H\,[g[u]h]\,\&\,\forall h\in H\,\exists g\in G\,[g[u]h]]$

I add a set of world W to the model, i.e. $M=\langle D,W,I\rangle$ and an interpretation function is relativised to worlds, i.e. I_w.[17] Evaluation of lexical relations is minimally refined as (25).[18] Note that only the distributive one matters for my purpose.[19]

16 (Sudo 2023) calls a set of possibilities an information state. In this paper, I call it a context.

17 One may alternatively take an interpretation function I not relative to worlds maps a relation R to an $n+1$-tuple of n entities and one possible world.

18 The functional alternatives of (24), (25a) and (25b) can be respectively defined as follows.

i. $c[u]=\{\langle w,H\rangle : w\in c\,\&\,\exists G\in c\,[\forall g\in G\,\exists h\in H\,[g[u]h]\,\&\,\forall h\in H\,\exists g\in G\,[g[u]h]]\}$

ii. $[\![\mathrm{R}(u_1)...(u_n)]\!](c)=\{\langle w,H\rangle : H\in c\,\&\,w\in c\,\&\,\forall h\in H\,[\langle h(u_1),...,h(u_n)\rangle\in I_w(\mathrm{R})]\}$ (distributive)

iii. $[\![\mathrm{R}(\cup u_1)...(\cup u_n)]\!](c)=\{\langle w,H\rangle : H\in c\,\&\,w\in c\,\&\,\langle H(u_1),...,H(u_n)\rangle\in I_w(\mathrm{R})]\}$ (collective)

19 One may alternatively assume that a relation R is *cumulative*, i.e. if $\langle x_1,x_2,...x_n\rangle\in I_w(\mathrm{R})$ and

(25) a. $[\![\mathrm{R}(u_1)...(u_n)]\!]=$
$\{\langle\langle w,G\rangle,\langle w,H\rangle\rangle : G = H \,\&\, \forall h \in H\,[\langle h(u_1),...,h(u_n)\rangle \in I_w(\mathrm{R})]\}$
(distributive)

b. $[\![\mathrm{R}(\cup u_1)...(\cup u_n)]\!]=\{\langle\langle w,G\rangle,\langle w,H\rangle\rangle : G = H \,\&\, \langle H(u_1),...,H(u_n)\rangle \in I_w(\mathrm{R})]\}$
(collective)

Since atomicity is an algebraic property of an entity, it is natural to assume that its evaluation is world-insensitive, but nothing hinges on this choice.[20]

(26) $[\![\mathrm{atom}(u)]\!]=\{\langle\langle w,G\rangle,\langle w,H\rangle\rangle : G = H \,\&\, \forall y\,[y \subseteq G(u) \to y = G(u)]]\}$

Lastly, his original analysis takes an update as **a function from the input context to the output context**. I define a context c as a set of possibilities and adopt an update function [ ] as a way to 'lift' relational denotation of DPlL formulae. $[\phi]$ denotes a function from the input context to the output context, i.e. $c[\phi] = \{\langle w,H\rangle : \exists G\,[\langle w,G\rangle \in c \,\&\, \langle w,G\rangle[\![\phi]\!]\langle w,H\rangle]\}$. A set of worlds and a set of plural information states can be retrieved from a context c.

$\langle y_1, y_2, ...y_n\rangle \in I_w(\mathrm{R})$, then $\langle x_1 + y_1, x_2 + y_2, ...x_n + y_n\rangle \in I_w(\mathrm{R})$. I notate a cumulative relation as R*. Then, one may assume a dynamically collective and statically cumulative evaluation.

i. $[\![\mathrm{R}(\cup u_1)...(\cup u_n)]\!](c) = \{\langle w,H\rangle : H \in c \,\&\, w \in c \,\&\, \langle H(u_1),...,H(u_n)\rangle \in I_w(\mathrm{R}^*)]\}$

20 Looking ahead a bit, consider the semantic contribution of "This coat has a pocket." I just assume that [[this coat]] is a constant k for an expository sake.

i. a. $\langle w,G\rangle[\mathrm{pocket}(u);\mathrm{pocket}([\![\text{this coat}]\!])(u)]\langle w,H\rangle$ iff
$G = H \,\&\, \forall h \in H\,[h(u) \in I_w(\mathrm{pocket}) \,\&\, \langle k,h(u)\rangle \in I_w(\mathrm{have})]]$

b. $\langle w,G\rangle[\mathrm{atom}(u)]\langle w,H\rangle$ iff $G = H \,\&\, \forall y\,[y \subseteq H(u) \to y = H(u)]$

The atomicity condition checks if the value of u under G is atomic, but it does not preclude the possibility that k has more than one pocket. For example, imagine a world w_1 such that:

ii. a. $\{a,b,c,d\} \subset I_{w_1}(\mathrm{pocket})$ b. $\{\langle k,a\rangle, \langle k,c\rangle, \langle k,d\rangle\} \subset I_{w_1}(\mathrm{have})$

Consider a possibility $\langle w_1,G\rangle$ such that $G(u) = a$. In this case, the atomicity condition is satisfied because a is atomic. Also, $\mathrm{pocket}(u);\mathrm{have}(k)(u)$ is satisfied because $a \in I_{w_1}(\mathrm{pocket})$ and $\langle k,a\rangle \in I_{w_1}(\mathrm{have})$. On this point, note that c and d are also pockets that the coat k has in w_1, but their presence does not prevent satisfaction of these conditions. Thus, "This coat has a pocket^u." is true iff this coat has **at least one** pocket, while it only introduces an atomic value to u. Even if one assumes that the atomicity condition requires the value of u under G to be atomic in w_1, this does not excludes c and d from $\mathrm{I}_{w_1}(\mathrm{pocket})$ nor excludes $\langle k,c\rangle$ and $\langle k,d\rangle$ from $I_{w_1}(\mathrm{have})$. Thus, a world-sensitive version of the atomicity condition arrives at the same conclusion: "This coat has a pocket^u." is true iff this coat has **at least one** pocket, while it only introduces an atomic value to u.

(27) a. $W(c) = \{w : \exists G \langle w, G\rangle \in c\}$ b. $A(c) = \{G : \exists w \langle w, G\rangle \in c\}$

With these definitions, three types of informativity can be defined. ϕ is dynamically more informative than ψ iff ϕ is truth-conditionally more informative than ψ or anaphorically more informative than ψ.

(28) Truth-conditional informativity

a. ϕ is **truth-conditionally more informative** than ψ iff for each information state c, $W(c[\phi]) \subseteq W(c[\psi])$, and there is at least one information state c' such that $W(c'[\psi]) \nsubseteq W(c'[\phi])$.

b. ϕ is **contextually truth-conditionally more informative** than ψ with respect to information state c iff $W(c[\phi]) \subset W(c[\psi])$.

(29) Anaphoric informativity

a. ϕ is **anaphorically more informative** than ψ iff for each information state c, $A(c[\phi]) \subseteq A(c[\psi])$, and there is at least one information state c' such that $A(c'[\psi]) \nsubseteq A(c'[\phi])$.

b. ϕ is **contextually anaphorically more informative** than ψ with respect to information state c iff $A(c[\phi]) \subset A(c[\psi])$.

(30) Dynamic informativity

a. ϕ is **dynamically more informative** than ψ iff for each information state c, $c[\phi] \subseteq c[\psi]$, and there is at least one information state c' such that $c'[\psi] \nsubseteq c'[\phi]$.

b. ϕ is **contextually dynamically more informative** than ψ with respect to information state c iff $c[\phi] \subset c[\psi]$.

Sudo (2023) defines *excludable alternatives* with this notion of dynamic informativity and exclusion of an alternative is addition of its dynamic negation. I simply define dynamic negation based on the functional notation with [ ].[21]

(31) a. ψ is an *excludable alternative* to ϕ iff ψ is an alternative to ϕ and ψ is dynamically more informative than ψ.

b. $c[\![\neg\phi]\!] = c - c[\phi]$

Now, consider a simple case. Since it is irrelevant, I assume that u_1 has a constant value across possibilities in (32). As the previous literature points out, “a pocket” and “pockets” are truth-conditionally equivalent if “pockets” is not inherently plural, i.e. both means “there is **at least one** pocket.”

21 I put aside the issue of dynamic double negation and disjunction.

(32) a. This coat^{u_1} has a pocket^{u_2}. b. This coat^{u_1} has pockets^{u_2}.

Sudo (2023) proposes that they are anaphorically not equivalent: "a pocket" just introduces an atomic value to u_2 and "pockets" may introduce non-atomic values to u_2. Thus, (32a) is dynamically more informative than (32b) because of this difference in anaphoric information. Putting aside the formal compositional details for now, the output contexts of (32a) and (32b) are informally given in (33a) and (33b).[22]

(33) a. $[\![(32a)]\!] = \{\langle w, H\rangle$: this coat has **at least one** pocket in w and $H(u_1)$ is an atomic pocket in w.}

b. $[\![(32b)]\!] = \{\langle w, H\rangle$: this coat has **at least one** pocket in w and **each part of** $H(u_1)$ is an atomic pocket in w.}

The fact that (33a) is dynamically more informative than (33b) motivates scalar inference when (32b) is uttered. Such inference is amount to dynamic negation of (33a). To zoom in to this exclusion process, consider the output context in (34). I notate an information state as a tuple of the values it assigns to drefs and a plural information state as a set of such tuples.[23] Also, I only take the minimal subset of output possibilities that are relevant for illustration.

22 Sudo (2023) himself does not offer a sub-clausally compositional implementation because it is orthogonal to his main purpose. Here, I briefly sketch one possible implementation. I adopt four types: type t for truth values, type s for possible worlds, type e for individuals, type π for drefs. A variable assignment is modelled as a function of type $\langle\pi, e\rangle$ and a set of variable assignments is type $\langle\langle\pi, e\rangle, t\rangle$. Following Dotlacil & Roelofsen (2021), I abbreviate type $\langle\langle\pi, e\rangle, t\rangle$ with a *meta-type m* and notate the type of a possibility with $\langle s \times m\rangle$. Now, I use the meta-type T as an abbreviation of $\langle\langle\langle s\times m\rangle, t\rangle, \langle\langle s\times m\rangle, t\rangle\rangle$, which is a function from a context to a context. Based on these meta-types, I further abbreviate dynamic existential quantification and evaluation of lexical relations. Informally speaking, an entity with the meta-type T is a functional update on the context.

(i) a. $\exists u = \lambda c_{\langle\langle s\times m\rangle, t\rangle}\, \lambda s_{\langle s\times m\rangle}\, \forall s' \in c\, [s'[u]s]$

b. $\mathrm{R}\{u_1\}...\{u_n\} = \lambda c_{\langle\langle s\times m\rangle, t\rangle}\, \lambda s_{\langle s\times m\rangle}\, [s \in c\ \&\ s[\mathrm{R}(u_1)...(u_n)]s]$

Now, the ordinal Montague and/or Heim and Kratzer-style sub-clausal compositionality can be emulated by replacing t in their translations with T. Some examples are given below.

(ii) a. $[\![\text{coat}]\!] = \lambda v_\pi\, [\text{coat}\{v\}]$

b. $[\![\text{have}]\!] = \lambda \mathrm{R}_{\langle\pi T, T\rangle}\, \lambda v_\pi\, \mathrm{R}(\lambda v'\, [\text{have}\{v'\}\{v\}])$

c. $[\![\text{a}]\!] = \lambda \mathrm{P}_{\langle\pi T\rangle}\, \mathrm{Q}_{\langle\pi T\rangle}\, \exists u\, [\text{atom}\{u\}\ \&\ \mathrm{P}\{u\}\ \&\ \mathrm{Q}\{u\}]$

d. $[\![\text{it}_{u_n}]\!] = \lambda \mathrm{P}_{\langle\pi T\rangle}\, [\mathrm{P}\{u_n\}]$

23 This notation differs from the one in Sudo (2023). Although it is just a notational matter here, various technical choice points lie here, e.g., whether one allows an information state to assign plural individuals and whether one rather takes an information state as a primitive Muskens (1996); Brasoveanu (2008) or not. Full exploration of these issues goes beyond the scope of this paper.

(34) a. $c[(32a)] = \{\langle w_1, H_1 = \{\langle k, \text{pocket}_1\rangle\}\rangle, \langle w_1, H_2 = \{\langle k, \text{pocket}_2\rangle\}\rangle, ...\}$

b. $c[(32b)] = \{\langle w_1, H_1 = \{\langle k, \text{pocket}_1\rangle\}\rangle, \langle w_1, H_2 = \{\langle k, \text{pocket}_2\rangle\}\rangle,$
$\langle w_1, H_3 = \{\langle k, \text{pocket}_1\rangle, \langle k, \text{pocket}_2\rangle\}\rangle, ...\}$

c. Exclusion: (34b)-(34a)= $\{\langle w_1, H_3 = \{\langle k,\text{pocket}_1\rangle, \langle k,\text{pocket}_2\rangle\}\rangle, ...\}$

Now, the dynamic implicature only excludes possibilities in which H assigns an atomic value to u_2, i.e. $H(u_2)$ is atomic. The value of u_2 is atomic in H_1 and H_2, but not in H_3.[24] Thus, the possibilities $\langle w_1, H_1\rangle$ and $\langle w_1, H_2\rangle$ are excluded. As a result, a plurality inference arises. Importantly, this analysis maintains the assumption that singular indefinites and bare plurals are truth-conditionally equivalent, i.e. w_1 is compatible with H_3 because singular indefinites and bare plurals both mean "at least one" in terms of truth-conditional information.

3.2 Sudo's solution to partial plurality inferences

One of the strongest advantages of Sudo's (2023) approach is its natural explanation of partial plurality inferences. Consider simplified version of the relevant examples.

(35) a. Every student^{u_1} wrote a paper^{u_2}.

b. Every students^{u_1} wrote papers^{u_2}.

On this point, recall that the alternative with a singular indefinite and the alternative with a bare plural are truth-conditionally equivalent. Thus, I only notate plural information states in this section: it is harmless to ignore worlds and omission of them rather increases readability. The relevant plural information states are given in (36). Again, I just take a minimal subset that is relevant for the discussion.

(36) a. $H_1 = \{\langle\text{student}_1,\text{paper}_1\rangle, \langle\text{student}_2,\text{paper}_2\rangle, \langle\text{student}_3,\text{paper}_3\rangle\}$

b. $H_2 = \{\langle\text{student}_1,\text{paper}_1\rangle, \langle\text{student}_2,\text{paper}_2\rangle, \langle\text{student}_3,\text{paper}_3\rangle, \langle\text{student}_3,\text{paper}_4\rangle\}$

c. $H_3 = \{\langle\text{student}_1,\text{paper}_1\rangle, \langle\text{student}_1,\text{paper}_2\rangle, \langle\text{student}_2,\text{paper}_3\rangle, \langle\text{student}_2,\text{paper}_4\rangle,$
$\langle\text{student}_3,\text{paper}_5\rangle, \langle\text{student}_3,\text{paper}_6\rangle\}$

On this point, recall that δ_{u_n} partitions a plural information state based on the values of u_n. In this case, "every" evaluates its scope with δ_{u_1} and the atomicity condition of "a paper" is evaluated with respect to each member of $H_{u_1=d}$.[25]

(37) a. $H_{1\,u_1=d} = \{\{\langle\text{student}_1,\text{paper}_1\rangle\}, \{\langle\text{student}_2,\text{paper}_2\rangle\}, \{\langle\text{student}_3,\text{paper}_3\rangle\}\}$

24 Note that for each $h \in H_3$, $h(u_2)$ is atomic. However, their 'global' value $H(u_2)$ is plural. Since the atomicity condition is a collective condition, $\langle w_1, H_3\rangle \notin c[(33a)]$.

25 A proper treatment of quantifiers in DPlL requires a maximality operator, but I ignore it because it is orthogonal to my purpose.

b. $H2_{u_1=d} = \{\{\langle \text{student}_1,\text{paper}_1\rangle\}, \{\langle \text{student}_2,\text{paper}_2\rangle\},$
$\{\langle \text{student}_3,\text{paper}_3\rangle, \langle \text{student}_3,\text{paper}_4\rangle\}\}$

c. $H3_{u_1=d} = \{\{\langle \text{student}_1,\text{paper}_1\rangle, \langle \text{student}_1,\text{paper}_2\rangle\},$
$\{\langle \text{student}_2,\text{paper}_3\rangle, \langle \text{student}_2,\text{paper}_4\rangle\}, \{\langle \text{student}_3,\text{paper}_5\rangle, \langle \text{student}_3,\text{paper}_6\rangle\}\}$

Considering these subsets of plural information states, the atomicity condition under δ_{u_1} is only satisfied in H_1. On the other hand, since "papers" does not encode the atomicity condition, (35b) is true with respect to all of H_1, H_2 and H_3. Thus, (35a) is dynamically more informative than (35b), trigerring a dynamic scalar implicature. This time, only H_1 is subtracted from the possible outputs of (35b). That is to say, H_2 survives through exclusion procedure. As a result, (35b) is predicted to induce a partial plurality inference: as long as one of the students corresponds to multiple papers, it is not excluded.[26]

3.3 A solution to partial plurality anti-presupposition

Now, I import this analysis to derive the partial plurality inferences with plural pronouns. I assume that a singular pronoun presupposes that its antecedent is atomic (Sauerland 2003; Sauerland et al. 2005; Brasoveanu 2008: a.o.). I repeat the relevant examples below.

(38) a. They$_{u_1}$ each submitted it$_{u_2}$.
b. They$_{u_1}$ each submitted them$_{u_2}$.

In this case, "it" is evaluated under the scope of δ_{u_1} provided from "each" and it requires that the value of u_2 is atomic in each member of $H_{u_1=d}$. Also, (38a) and (38b) are contextually equivalent and minimally differ in terms of the atomicity presupposition of (38a). This leads to competition in terms of the strength of presupposition. I adopt the principle of *Maximise Presupposition!* (MP) (Heim 1991), refining it in the current dynamic setting.

(39) **Maximise Presupposition!**: If ϕ has an alternative ψ with respect to the input set of possibilities c, one must use ψ, if
a. the assertive meanings of ϕ and ψ are contextually dynamically equivalent,
b. the presuppositions of ψ are dynamically more informative than those of ϕ, and
c. the presuppositions of ψ are met in c.

26 Note that this inference follows from global calculation of scalar implicature, which is much less controversial than local calculation of scalar implicature. Thus, this analysis is compatible with the pragmatic theory and the grammatical theory of scalar implicature.

I define contextual dynamic equivalence as (40).

(40) ϕ and ψ are **contextually dynamically equivalent** with respect to information state c iff $c[\phi] = c[\psi]$.

Since (38a) and (38b) minimally differ in terms of the atomicity presupposition, they are contextually dynamically equivalent. In addition, (38a) is dynamically more informative than (38b) due to presence of the atomicity presupposition.

Now, let's see how it works. First, imagine (38a) and (38b) are uttered after (35a). Since the output of (35a) can contain H_1, but not H_2 and H_3, H_1 serves as an input for (38a) and (38b). In this case, the atomicity presupposition of (38a) is met: the value of u_2 is atomic in each member of $H_{u_2=d}$. As a result, (39) makes (38b) infelicitous. Second, imagine (38a) and (38b) are uttered after (35b). Due to competition with (35a), (35b) triggers dynamic scalar implicature. Thus, the output of (35b) contain H_2 and H_3. Since the atomicity presupposition of (38a) is met in neither H_2 nor in H_3, (38a) is correctly predicted to be infelicitous. For the same reason, (39) does not make (38b) infelicitous because the presupposition of its stronger alternative is not met. Importantly, this blocking with (39) works analogously to scalar reasoning in Sudo (2023), i.e. it only excludes every plural information state H in which the value of an indefinite or a pronoun stores an atomic value in **each member of** H. Thus, if a plural information state stores a non-atomic value in at least one of its members, it survives through exclusion. On this point, it is crucial that (39) can be checked **globally**, i.e. above the scope of δ. If it is checked under the scope of δ, it wrongly predicts a total plurality inference, i.e. the value of a plural pronoun has to be plural in each member of a plural information state. Summing up, a simple extension of Sudo's (2023) dynamic implicature approach accounts for partial plurality inferences with plural pronouns. The key feature is that presuppositional competition may be checked globally.

3.4 Further support

In this section, I briefly discuss age-old observations that fit well with the assumption that singular pronouns are truth-conditionally not more informative but anaphorically more informative than plural pronouns. For example, expressions such as "one or two" and "at least one" cannot antecedent a subsequent singular pronoun.

(41) a. Mary^{u_1} wrote **one or two** articles^{u_2}.

b. She$_{u_1}$ sent {*it / them}$_{u_2}$ to L&P. (Krifka 1996)

(41a) is still true even if it turns out that Mary just wrote one article and thus "them" should be truth-conditionally compatible with an atomic individual. Furthermore, consider cases of strong readings of donkey pronouns. (42) has a reading that every farmer who owns a donkey cherishes every donkey the farmer owns. This suggests that the truth-conditional component of "it" is compatible with plural donkeys.[27]

(42) Every farmer^{u_1} who owns a donkey^{u_2} cherishes it$_{u_2}$.

The choice of pronoun is rather sensitive to the anrphoric potential of its antecedent: use of "donkeys" prohibits use of "it."

(43) Every farmer^{u_1} who owns donkeys^{u_2} cherishes $\{$#it / them$\}_{u_2}$.

These observations suggest that the number contrast in pronouns is in parallel with the number contrast in indefinites. A singular pronoun and a plural pronoun are both truth-conditionally compatible with both an atomic individual and non-atomic individuals in terms of truth-conditional information. They only contrast in terms of anaphoric information: a singular pronoun conveys a presupposition with respect to anaphoric information of its antecedent and a plural pronoun does not.

4 Local MP and animacy

In this section, I discuss two consequences of the proposed account. First, I discuss intra-sentential resolution of inanimate "they" and discuss its implication to local MP. Second, I discuss the effect of animacy in cases of intra-sentential plural anaphora and its implication to gender-neutral singular "they."

4.1 Local MP and intra-sentential anaphora

In cases of in-scope binding, plural pronouns result in infelicity as (44) exemplifies.[28]

(44) a. Every poster^{u_1} is located in $\{$its / *their$\}_{u_1}$ right place^{u_2}.

(Patrick Elliot, p.c.)

b. The librarian^{u_1} returned every book^{u_2} to $\{$its / *their$\}_{u_2}$ original place^{u_3}.

In (44), the atomicity presupposition of "it" is already satisfied when it is bound by the distributive universal quantifier "every."[29] If MP is checked after this local satisfaction of the atomicity presupposition, the plurality anti-presupposition would

27 I do not discuss donkey anaphora further in this paper, but one may pursue an approach that semantically underspecifies the weak/strong distinction with respect to the truth-conditional informativity and pragmatically resolves it. Although I do not attempt to make them compatible with my approach, Champollion, Bumford & Henderson (2019); Chatain (2018) seem to implement such an approach.

28 I deeply thank to Patrick Elliot (p.c.) for the relevant data and discussion.

29 Note that the plural marking of the possessee noun does not matter.

not be observed whether it is total or partial, i.e. singular-plural distinction is neutralised. However, the infelicity of (44) suggests that this is not the case. Therefore, MP has to be checked before the local satisfaction of the atomicity presupposition. This is in line with the previous literature on presupposition competition. Percus (2006) reports that the presupposition of "both" locally competes with "all" even when its presupposition is locally satisfied.

(45) Everyone with **exactly two students** assigned the same exercise to {both / #all} his students. (Percus 2006)

Cases like this lead to the view that MP is checked against **each sub-formula** of ϕ (Singh 2011; Schlenker 2012; Anvari & Blumberg 2021).

(46) **Local MP**: Check that Maximise Presupposition! is satisfied for each sub-formula S embedded in ϕ in S's local context c'. (Singh 2011)

Now, (46) correctly predicts (44) to be infelicitous. However, it can be too strong: to generate a partial plurality anti-presupposition, MP has to be checked against a sub-formula that is not contained under the scope of δ. Otherwise, only a total plurality anti-presupposition is generated. It raises a dilemma. If MP is checked against a sub-formula contained within the δ operator, it accounts for (6), but it wrongly predicts (44) to be felicitous. If it is checked against a sub-formula that is not contained under the scope of the δ operator, it accounts for (44), but wrongly predicts (6) to be infelicitous.[30] Thus, (46) has to be relaxed so that MP can be checked globally in cases of inter-sentential plural anaphora while it has to be checked locally in cases of intra-sentential anaphora. An intuitive solution is to check MP against the most local sub-constituent (cf. Anvari & Blumberg 2021) that contains a pronoun and its antecedent. The precise implementation of it requires consideration of several technical issues and I leave it for future research.

i. *Every poster is located in their right places.

ii. *The librarian returned every book to their original places.

30 One may regard the atomicity condition as an utterance-level condition, e.g., *Admissibility Condition for Assignment Functions* (Sudo 2012), and assume that plural pronouns do not convey such a condition. Then, the plurality requirement of plural pronouns can be analysed as an utterance-level (obligatory) implicature. Since it is not a presupposition, it is not subject to (46). Sudo (2012) suggests that if an assignment is modified within a sentence via Predicate Abstraction, the modified assignment does not have to comply with this condition. It makes correct predictions for animate dependent plural pronouns, but it makes wrong predictions for inanimate ones. A remedy is to let the admissibility condition trigger an (obligatory) implicature at the point of its evaluation. Then, a plural pronoun locally competes with a singular pronoun in cases of in-scope binding and makes correct predictions for inanimate plural pronouns. In this approach, however, animate dependent plural pronouns have to be analysed as singular "they." See the next section for more discussion.

4.2 Effects of animacy

So far, I mainly concerned with inanimate uses of plural pronoun "they." The behaviour of its animate uses seems to differ from the behaviour of its inanimate uses. Recall that the animate "their" can be bound by "every passenger" in (1b).

(1b) Every passenger^{u_1} of this flight lost their$_{u_1}$ suitcases^{u_2}. (Sudo 2023)

The felicity of (1b) contrasts with the infelicity of (44). (47) shows a minimal pair of animate "their" and inanimate "their."[31]

(47) a. *Every performance^{u_1} seems to be violent to their$_{u_1}$ audience(s)^{u_2}.
b. Every performer^{u_1} seems to be violent to their$_{u_1}$ audience(s)^{u_2}.

This contrast partially carries over to the cases of *dependent plural pronouns* although it interacts with quasi-animate construals of content-denoting inanimates. Rullmann (2003) points out that (animate) plural pronouns may have a singular interpretation when it takes a quantificational antecedent.

(48) The first year students^{u_1} all think that **they**$_{u_1}$ are the smartest student. (Sudo 2014)

The embedded predicate "are the smartest student" blocks the collective reading, i.e. the students collectively qualify as the smartest group of students. Also, its non-co-varying distributive reading is incoherent because it cannot be the case that every student is the smartest, i.e. there can be at most one smartest student. Thus, the only intelligeble reading is that each student x thinks that x is the smartest student. (48) is felicitous under this reading: the (animate) plural pronoun has a reading of a singular bound variable. This is expected if MP may be checked globally: the atomicity presupposition has already been satisfied when MP applies and thus two alternatives do not compete.[32] However, it wrongly predicts (44) to be felicitous.

31 There seems to be an inter-speaker variation in cases with content-denoting inanimate nouns. (ib) is fine modulo the unnaturalness of using "owner(s)." In contrast, the acceptability of (ia) is subject to variation. This variation seems to be reduced to the availability of quasi-animate construals of content-denoting inanimate nouns. Importantly, the speaker who accepted (ia) still rejects (ic). I leave the precise investigation of this for future research.

i. a. % Every math textbook^{u_1} seems to be useful to their$_{u_1}$ owner(s)^{u_2}.
b. Every math teacher^{u_1} seems to be useful to their$_{u_1}$ owner(s)^{u_2}.
c. *Every knife^{u_1} seems to be dangerous to their$_{u_1}$ owner(s)^{u_2}.

32 Recall that some speakers accept plural pronouns in (4) to obtain the dependent reading. This reading can be derived if such speakers have an option to check MP against a sub-formula that is not contained under the scope of δ. I leave the precise examination of individual variation to future research.

Furthermore, inanimate "they" shows a nuanced behaviour in cases of inter-clausal binding. For some speakers, (49) with "they" only has an incoherent reading that the math textbooks are each the most accessible textbook in the field. This suggests that the singular variable reading analogous to (48) is unavailable with inanimate "they." However, some other speaker accepted both. One interpretation is that they allow quasi-animate reading of content-denoting inanimate nouns.[33]

(49) a. % **Every** math textbook^{u_1} says that they$_{u_1}$ are the most accessible textbook in the field.

b. % **All** the math textbooks^{u_1} say that they$_{u_1}$ are the most accessible textbook in the field.

This may suggest that either (i) singular variable "they" is derived via its animate singular use or (ii) interaction between the atomicity presupposition and other presuppositions, e.g., gender, leads to difference in locality of MP checking. At this point, the option (i) can account for the data presented in this section while the option (ii) requires much more to be properly implemented.[34]

5 Conclusion

In this paper, I discussed partial plurality inferences of a plural pronoun with respect to its antecedent under the context of quantificational subordination. This inference follows if (i) plural pronouns are semantically number-neutral and (ii) their plurality requirement comes from global pragmatic strengthening. The recipe of dynamic scalar implicature in Sudo (2023) can directly be applied to it as a recipe of dynamic presuppotional competition. This analysis has non-trivial consequences for locality of MP checking and the source of singular-variable use of "they."

33 Indeed, this speaker accepted (ia) in Footnote 31.

34 To compare these options, one shall look at a language that lacks a gender-neutral singular construal of a plural pronoun, e.g., German. I leave precise investigation for future research, but German allows dependent plural pronouns for both animate and inanimate plural "sie" (they.)

i. Alle Mathematik-Lehrbücher sagen, dass sie das verständlichste Lehrbuch in diesem
all math-textbooks say that they the most accessible textbook in the
Fachgebiet sind.
field are

"All the math textbooks say that they are the most accessible textbook in the field."

i. Alle Mathematiklehrer sagen, dass sie der verständlichste Lehrer in diesem Fachgebiet sind.
all math-teachers say that they the most accessible teacher in the field are

"All the math teachers say that they are the most accessible textbook in the field."

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