Processing cataphoric *they* amidst pronominal innovation

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Abstract: Upon encountering a potentially cataphoric pronoun during incremental processing, comprehenders anticipate a feature-matched postcedent nominal in the nearest grammatical position. This study asks whether sociolinguistic variables can predict the details of this active processing strategy for cataphora, leveraging an ongoing change in the American English pronoun system. The types of referents compatible with the *they*-series of pronouns is expanding, with innovative speakers (often younger people, and transgender/nonbinary people) accepting definite singular referents. Reading-time results from a lexicality maze experiment show that cataphoric *he* and *she* evoke strong expectations for a singular postcedent among all speakers. Effects associated with cataphoric *they* are more nuanced; trends suggest that younger and trans/nonbinary participants countenance singular postdents to *they* more than their older and cisgender counterparts, but the nonsignificance of age and gender orientation show that these coarse-grained demographic factors are not strong predictors of real-time processing behavior. There is also an unexpected asymmetry in the timecourse of singular vs. plural mismatch effects, suggesting that the many uses of *they* (not just innovative ones) influence the processing of referential dependencies involving that pronoun among all speakers.

1. Introduction

Cataphoric pronouns are those which precede their referents. A cataphor might appear in a left-edge adjunct clause, where its nearest grammatical postcedent is the matrix subject (Carden 1982, Reinhart 1983). Because English's *he-* and *she*-series of pronouns presuppose the gender of their referents (Sauerland 2008, Sudo 2012), a cataphoric dependency will be infelicitous if the pronoun and R-expression are discordant in gender. Compare examples in 1, where subscripts indicate intended coreference.

(1)   a.   After *she*$_1$ smiled, *the bride*$_1$ started laughing.
    b.   #After *he*$_1$ smiled, *the bride*$_1$ started laughing.
    c.   After *he*$_1$ smiled, *the groom*$_1$ started laughing.
    d.   #After *she*$_1$ smiled, *the groom*$_1$ started laughing.

Comprehenders across languages seem to process cataphors actively, anticipating a postcedent with appropriate features at the nearest grammatical position (Van Gompel & Liversedge 2003, et seq). Evidence comes from Gender Mismatch Effects, which are well documented in the matrix-subject position of sentences like those above. Following a potentially cataphoric pronoun, a feminine-biased noun like *bride* will be read more slowly if that pronoun is masculine (1b) than if the pronoun is feminine (1a); vice versa for *groom* (1d vs. 1c). The syntactictic positions where such mismatch effects arise shows that the active processing strategy for cataphora is persistent (Giskes & Kush 2021), sensitive to

grammatical constraints like Binding conditions (Kazanina et al. 2007, Kush & Dillon 2021), and that it involves abstract grammatical predictions (Giskes & Kush 2022).

All else being equal, we expect any grammatical property of a pronoun that constrains its cataphoric reference possibilities to influence the comprehender's active search for a postcedent. Pronouns make number distinctions in English and many other languages, and indeed there is some evidence of Number Mismatch Effects in cataphoric processing (Van Gompel & Liversedge 2003, exp. 3; Giskes & Kush 2022) that parallel the better documented Gender Mismatch paradigm. That is, after potentially cataphoric feminine-singular *she*, the plural subject *brides* (2) is harder to process than singular *bride* (1a), just as masculine-singular *groom* (1d) is.

(2)   #After *she*$_1$ smiled, *the brides*$_1$ started laughing.

Number Mismatch Effects, though, deserve deeper investigation. For reasons that are plausibly language-general, the semantics of number is quite different from that of gender (e.g., Schwartzschild 1996, Sauerland et al. 2005, Harbour 2014). For instance, plurals at least offer the possibility of split antecedence (3). It could be that evaluating whether a potential postcedent is compatible with a cataphor's number features is therefore crucially different from evaluating gender compatibility — perhaps in time course of the processing effects, or the types of linguistic cues that modulate the expectations.

(3)   a.   ?After *she*$_1$ smiled, *the newlyweds*$_{1+2}$ started laughing.
       b.   ?After *they*$_{1+2}$ smiled, *the bride*$_1$ started laughing.

And, for English-specific reasons, it is not trivial to compare the plural pronoun *they* to the singular pronouns *he* and *she*. Innovative uses of *they* with morphosyntactically singular referents have been gaining currency for centuries (Balhorn 2004, Bjorkman 2017, Konnelly & Cowper 2020). Well established is 'quantified *they*', where the pronoun is interpreted as a variable bound by a quantifier with a high-animacy restrictor (4a). More innovative uses involve referents to singular *they* that are higher on the referentiality hierarchy (Conrod 2019). Some speakers naturally use *they* to refer even to specific definite entities, especially in contexts where gender is 'obviated' (4b) – perhaps the referent is unknown, anonymized, or hypothetical, or their gender is insufficiently relevant to specify. Finally, many transgender and nonbinary people request reference with singular *they* (4c) in all linguistic contexts, as a gender-neutral alternative to *he* and *she*; trans/nonbinary speakers and those in community with them use 'nonbinary' *they* fluently. The obviated and nonbinary innovative uses are subtypes of 'definite singular *they*' (Conrod 2019), with the latter being potentially 'more definite' and more innovative.

(4)   a.   After *they*$_1$ smiled, *each journalist*$_1$ started laughing.   Quantified *they*
       b.   After *they*$_1$ smiled, *the journalist*$_1$ started laughing.   Obviated *they*
       c.   After *they*$_1$ smiled, *Masha Gessen*$_1$ started laughing.   Nonbinary *they*

Synthesizing these observations, we ask whether ongoing changes associated with *they* are measurably reflected in real-time sentence-processing behavior. We hypothesize that comprehenders in social groups observed to accept innovative definite singular uses of *they* (namely, speakers from younger generations, and speakers identifying as trans/nonbinary) will exhibit weaker Number Mismatch Effects after *they* than

those in less innovative groups (older and cisgender speakers). That is, innovative comprehenders will face little if any processing difficulty at singular matrix subjects that follow potentially cataphoric *they* (as in 4b,c), compared to possible postcedents that are plural. The present reading-time experiment does not clearly bear out this prediction, showing that coarse-grained demographic variables are not reliable predictors of individual variation in processing times relating to this particular change in progress. However, results still provide insight into the timecourse of evaluating referential dependencies vis-a-vis number features, and our methodological approach offers a promising way to combine insights from psycholinguistics and sociolinguistics.

2. Previous research

This section provides background information on the psycholinguistics of referential dependencies and the sociolinguistics of singular *they*, contextualizing the design and results of our experiment.

2.1 Processing cataphora and referential dependencies involving *they*

Some early sentence-processing research investigated how exposure to potentially cataphoric *they* influences the interpretation of nominals like *frying eggs*, which are syntactically ambiguous: interpretable as either plural noun phrases modified by progressive participles, or singular gerundial phrases with plural complements. Tyler & Marslen-Wilson (1977) found preambles including cataphoric *they* facilitated participants' ability to repeat number-inflected verbs that disambiguated such nominals as plural (though their plural-biasing stimuli did not always involve cataphoric *they*). Cowart & Cairns (1987) found similar results, systematically using preambles with *they* that also manipulated other semantic–pragmatic factors. These studies provided early evidence that the processing profile of ambiguous words and phrases is modulated by their preceding context.

Building on these observations, Van Gompel & Liversedge (2003) turned to processing effects associated with cataphors' gender features. In two eyetracking-while-reading experiments, they found clear evidence of Gender Mismatch Effects in stimuli shaped like those above (1), with slowdowns in early and late eye-movement measures that emerged just after matrix-subject nouns with lexically or stereotypically incongruent gender. A third experiment manipulated the number features of the cataphor and matrix-clause nouns, using itemsets like 5. In conditions where the matrix subject was incongruent in number features to the preceding pronoun (5b,c), a Number Mismatch Effect emerges just after the critical noun region, paralleling the Gender Mismatch Effect.

(5) a. When *he* appeared, *the king* immediately greeted the boys very warmly. ***s/he…SG***
     b. When *he* appeared, *the boys* immediately greeted the king very warmly. ***s/he…PL***
     c. When *they* appeared, *the king* immediately greeted the boys very warmly. ***they…SG***
     d. When *they* appeared, *the boys* immediately greeted the king very warmly. ***they…PL***

This study has inspired a number of investigations into the mechanisms involved in processing cataphora. Of particular interest is whether comprehenders countenance possible referential dependencies that are ruled out by grammatical constraints. The answer seems to be no: comprehenders actively search for

postcedents to cataphors only in syntactic positions permitted by their grammars. Studying English, Kazanina et al. (2007) found that Gender Mismatch Effects do not emerge in syntactic positions where coreference between a pronoun and R-expression is ruled out by Condition C; Yoshida et al. (2014) find sensitivity to Condition C even within islands; Dillon & Kush (2022) found that comprehenders are sensitive to Condition B when evaluating possible referents to cataphoric PRO. In general this grammatically-sensitive active-search strategy to processing cataphors seems to be crosslinguistically robust (cf. Kazanina & Phillips 2010 on Russian; Pablos et al. 2015 on Dutch), though some findings complicate the picture a bit — Drummer & Felser (2018) and Patterson & Felser (2019) find evidence that German comprehenders temporarily consider postcedents ruled out by Condition C.

Overall, these findings suggest a strong parallel between the processing of cataphora and the processing of filler–gap dependencies (Kazanina et al. 2007), with feature mismatch effects in these sentences parallelling the Filled-Gap Effects well documented in relative clauses and *wh*-questions (Stowe 1986, Frazier & Clifton 1989, et seq). Recent studies highlight the parallel. Giskes & Kush (2021) find Gender Mismatch Effects in Norwegian and English at both matrix-subject and matrix-object positions, demonstrating that the active search for a postcedent is persistent. And, leveraging V2 word order and verbal phi-agreement in Dutch, Giskes & Kush (2022) show that the search triggered by a potential cataphor is for abstract features, not simply particular nouns. In stimuli like 6, notice that the matrix-clause verb appears before the subject (since the preposed adjunct clause occupies the clause-initial position that the verb immediately follows). That verb's agreement inflection indicates the number features of the upcoming subject, and this morphology alone is sufficient to trigger a Number Mismatch Effect in conditions like 6b,c. In other words, the agreement cue lets the comprehender anticipate an abstract matrix subject, yet unencountered, whose phi-features can be inferred and matched against the cataphoric pronoun's.

(6) a. ***Cataphor.SG…Verb.SG***
Nadat *hij* de steutels had ingeleverd, *sleepte* de extreem chagrijnege
after he the keys had.SG turned_in dragged.SG the extremely annoyed
   assistent de koffers van de muzikanten naar de lobby.
   assistant the suitcases of the musicians to the lobby
"After *he* had turned in the keys, the extremely annoyed assistant *dragged* [SG.AGR] the suitcases of the musicians to the lobby."

   b. ***Cataphor.SG…Verb.PL***
Nadat *hij* de steutels had ingeleverd, *sleepten* de extreem chagrijnege
after he the keys had.SG turned_in dragged.PL the extremely annoyed
   assistenten de koffers van de muzikant naar de lobby.
   assistants the suitcases of the musician to the lobby
"After *he* had turned in the keys, the extremely annoyed assistants *dragged* [PL.AGR] the suitcases of the musician to the lobby."

c. ***Cataphor.PL…Verb.SG***

    Nadat *zij* de steutels hadden ingeleverd, *sleepte*   de extreem   chagrijnege

    after they the keys   had.PL turned_in   dragged.SG the extremely annoyed

        assistent   de   koffers   van de   muzikanten naar de lobby.

        assistant   the   suitcases of   the   musicians   to   the lobby

    "After *they* had turned in the keys, the extremely annoyed assistant *dragged* [SG.AGR] the suitcases of the musicians to the lobby."

d. ***Cataphor.PL…Verb.PL***

    Nadat *zij* de steutels hadden ingeleverd, *sleepten*   de extreem   chagrijnege

    after they the keys   had.PL turned_in   dragged.PL the extremely annoyed

        assistenten de   koffers   van de   muzikant   naar de lobby.

        assistants   the   suitcases of   the   musician   to   the lobby

    "After *they* had turned in the keys, the extremely annoyed assistants *dragged* [PL.AGR] the suitcases of the musician to the lobby."

It is remarkable that pronouns in these syntactic positions trigger an active search, since cataphoric dependencies are never obligatory; pronouns can always have sentence-external referents (7). This contrasts with filler–gap dependencies, where the $\overline{\text{A}}$-filler is necessarily paired with an empty argument position (setting aside the possibility of resumption).

(7)   After *she*$_1$ smiled, *the groom*$_2$ started laughing.

The anticipation of a cataphoric dependency seems to be a strategy for avoiding so-called unheralded pronouns: ones whose referents are not established in the discourse (Gerrig 1986). While not unusual in naturalistic speech given particular discourse contexts (Gerrig et al. 2011), unheralded pronouns in psycholinguistics experiments — where sentences are presented with very minimal context, if any — typically cause processing difficulty (Greene et al. 1994, Filik and Sandford 2008, Filik et al. 2008). Notably, unheralded *he* and *she* have been found to be harder to process than unheralded *they* (Sanford et al 2007). This likely reflects the fact that *they* has yet another standard usage, to stand in for a generic, unnamed 'institution' (8). The possibility of an institutional, non-referential reading of *they* means the pronoun offers the comprehender a way out of accommodating an unheralded referent. Positing a cataphoric dependency is another way: in a left-edge subordinate clause, a pronoun might be incrementally unheralded, but if it is a cataphor the referent can be expected in the upcoming clause.

(8)   *They* make great wine in Italy.   Institutional *they*

We are not aware of research into the real-time processing which attempts to disentangle referential plural, quantified, and institutional uses of *they* in cataphora. However, there has been some work on quantified and gender-neutral *they* in anaphora. Foertch and Gernsbacher (1997) analyzed per-character reading times of sentences with pronouns whose antecedents were indefinite or definite noun phrases, with or without lexical gender biases. Conditions with *they* only had a processing advantage when the antecedent was an indefinite pronoun like *anybody*; *they* was also relatively harder to process when the antecedent was biased masculine than when it was biased feminine. In an eyetracking experiment,

Sanford and Filik (2007) found Number Mismatch Effects for *s/he* and *they* preceded by plural or singular indefinite antecedents, respectively. However, the effect was asymmetrical: the *PL…s/he* mismatch impeded processing in early and late eye-movement measures; the *SG…they* effect manifested only in late measures.

More recently, Han, Moulton, and colleagues have investigated off-line acceptability and real-time processing of singular *they*. Moulton et al. (2020) found degraded acceptability for *they* in contexts with an established gender-neutral referent that is not mentioned sentence-internally. Han and Moulton (2022) compared quantified and referential antecedents with or without nouns with gender bias. They found an acceptability advantage for bound-variable *they* relative *s/he* when the restrictor was gender-neutral, and a disadvantage for *they* with either kind of referential antecedent. In corresponding self-paced reading experiments, they found longer reading times when *they* had a referential, gender-biased antecedent. Moulton et al. (2022) also found high acceptability for bound-variable *they*, highest when the quantifier was *each* compared to *every* or *all*; in their SPR studies, bound-variable *they* generally facilitated processing relative to *s/he*, whatever the restrictor's lexical gender bias.

2.2 Sociolinguistics of singular *they*

Uses of *they* with morphosyntactically singular referents that are indefinite or quantified is well attested across the history of English, and have only been increasing in recent centuries (Balhorn 1994). But only more recently have uses of *they* referring to definite singular discourse entities (4b,c) become frequent and gained theoretical attention (Bjorkman 2017, Konnelly & Cowper 2020).

Sociolinguistic research has documented effects on acceptability and production of definite singular *they*, connected to both social variables and linguistic context. In a large internet-based study, Conrod (2019) finds main effects of age, gender, and transgender identity on the acceptability of definite singular *they*, with younger and trans participants rating it better. Ratings were negatively correlated with age among non-trans but not trans people, and among men and women but not people who identify as neither. Adopting the Apparent Time Hypothesis (Weinreich et al. 1968), the effects of age on acceptability show that the emergence of definite singular *they* is a change in progress: younger speakers' linguistic experience has a relatively higher proportion of definite singular observations of *they* than older speakers', hence the negative correlation. Conrod also found that effect of age was stronger when *they* had a proper name antecedent than a non-specific definite noun, indicating that nonbinary *they* (4c) is relatively more innovative that obviated *they* (4b).

Besides gender(-orientation) and age, ideology has been demonstrated to be a good predictor of the acceptability of definite singular *they*: individuals with more prescriptive views on language and with more traditional social beliefs about gender are less likely to accept innovative uses of *they* in off-line acceptability tasks and sentiment-analysis studies (Bradley 2020; Hekanaho 2020, 2022).

3. Experiment

While singular *they* is gaining attention in psycholinguistics and experimental syntax–semantics, few experiments have investigated correlations between comprehension behavior and sociolinguistic variables. The present study uses age and gender orientation as between-subject factors in a reading-time study on cataphora. We expect that the number expectations evoked by potentially cataphoric *they* vary according to how innovatively participants use the pronoun. Since off-line acceptability of definite singular *they* is higher among younger and trans/nonbinary speakers, we hypothesize that those groups will exhibit smaller Number Mismatch Effects than older and cisgender speakers. (Note that the 'mismatch' we refer to is between the *morphosyntactic* number features of a cataphor and its potential postcedent, rather than a semantic notion of number; insofar as it controls plural verb agreement, 'singular' *they* is morphosyntactically plural even for the most innovative speaker.)

3.1 Design

Materials

Thirty-two itemsets were constructed with a 2×2 design, manipulating the potentially cataphoric pronoun (*s/he* or *they*) and the number features of the matrix subject (singular or plural). That subject was always a definite noun, chosen from a list of gender-normed lexical items found not to have a strong masculine or feminine bias (Misersky et al. 2014). A sample itemset follows.

(9)   a.   ***s/he…SG***
      When **she** exercises at home, the **reporter** misses the librarians' enthusiastic encouragement.
   b.   ***s/he…PL***
      When **she** exercises at home, the **reporters** miss the librarian's enthusiastic encouragement.
   c.   ***they…SG***
      When **they** exercise at home, the **reporter** misses the librarians' enthusiastic encouragement.
   d.   ***they…PL***
      When **they** exercise at home, the **reporters** miss the librarian's enthusiastic encouragement.

Note that the matrix clause always contained a second noun with the opposite number feature; this ensured that some cataphoric dependency was always globally available in the mismatch conditions (9b,c), even for participants less familiar with definite singular *they*. Though no norming study was conducted to assess the coherence relations and possible referential dependencies between the clauses, care was taken to make either noun a plausible postcedent to the cataphor.

Sixty-four filler sentences of comparable length and complexity were also constructed. Target items were distributed according to the Latin Square method, and shuffled among the fillers. Half of all items were followed by a comprehension question, taking the form of a sentence-recognition probe (*Was this the sentence you just read?*). Due to a coding error, software did not log responses to the comprehension questions.

Methods and procedure

Stimuli were presented using the Lexicality Maze methodology (Freedman & Forster 1985, Boyce et al. 2020). The L-Maze presents participants with two words at a time: a real word and a nonce word, displayed side-by-side in a random order. (Nonce words were generated automatically using orthographic trigram frequencies calculated from Mary Shelley's *Frankenstein*.) Participants were instructed to select the real word using the 'e' or 'i' keys on their keyboard. A correct choice would display the next pair of words; the real word of that pair would continue the sentence; and so on. An incorrect choice would prompt a feedback message, after which the participant could try again and continue with the rest of the sentence. Figure 1 schematizes an L-Maze trial.
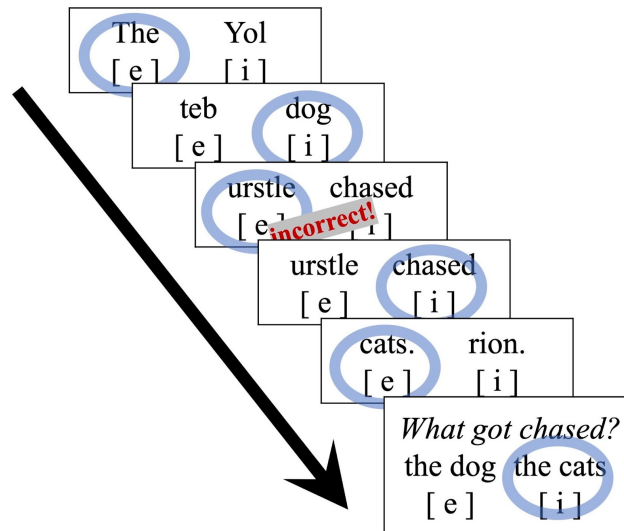

Figure 1: Illustration of the L-Maze methodology. Participant selections, input with the keyboard, are indicated with blue circles.

The experiment was hosted on PCIbex (Zehr & Schwarz 2018). After consenting to the study, participants read instructions and were introduced to the L-Maze methodology with three practice trials. There were two opportunities during the experiment for participants to take a short break, at about one-third and two-thirds the way through. Upon completion, there were a few optional debriefing questions addressing the task difficulty and any linguistic patterns noticed in the stimuli.

Participants

125 participants living in the United States were recruited via Prolific, using the platform's demographic filters to find participants of different gender orientations. Five of them listed a native language other than English in their Prolific demographic profiles; we set aside their data for all analyses.

The remaining 120 participants comprised 60 trans and nonbinary people, and 60 cisgender men and women. Age was not carefully controlled, but the sample ended up representing a range of generations. The median age across all participants was 32 years. A more detailed breakdown is provided in Table 1.

		N_{Subj}	Age range (median)
Trans/nonbinary	**Trans men**	13	19–49 (31.5)
	Trans women	6	20–42 (24)
	Other gender orientation	41	19–75 (32)
Cisgender	**Cis men**	38	18–65 (32.5)
	Cis women	22	21–79 (45)
All participants		120	18–79 (32)

Table 1: Breakdown of participant demographics; ages given in years

Analysis

Within any trial, observations at or after an incorrect lexicality decision were excluded from analysis. The remaining word-by-word reaction times (86% of all observations) were log-transformed and analyzed with linear mixed effects models, using the *R* package *lme4* (Bates et al. 2015). The fixed effects were *Cataphor*, *Match*, and either *Age* or *Gender*. The within-subject factors were sum-coded in the following way: *s/he* = –½ (9a,b) and *they* = +½ (9c,d); *match* = –½ (9a,d) and *mismatch* = +½ (9b,c). The between-subject factors were also sum-coded: *younger-than-median-age* = –½ and *not-younger-than-median-age* = +½; *trans/nonbinary* = –½ and *cisgender* = +½. Complexity of random-effect structure was decreased until models converged (Barr et al. 2013). One nonbinary participant's Prolific demographics did not list their age; they were excluded from age-related analyses.

3.2 Results

Log-transformed word-by-word reaction times pooled across all participants are plotted in Figure 2. Plots in Figure 3 partition RTs at critical regions by age and gender orientation. Visual inspection reveals a clear Number Mismatch Effect emerging at the matrix-subject NOUN region in the *s/he…PL* condition (9b; light grey) for all participants, which persists into the spillover region (W08). Insofar as there is a parallel effect for the *they…SG* condition (9c; light gold), it does not emerge until the spillover region. Comparing across demographic bins, numerical trends align with our hypothesis: on average, older and cisgender comprehenders have more pronounced Number Mismatch Effects in the *they…SG* condition.
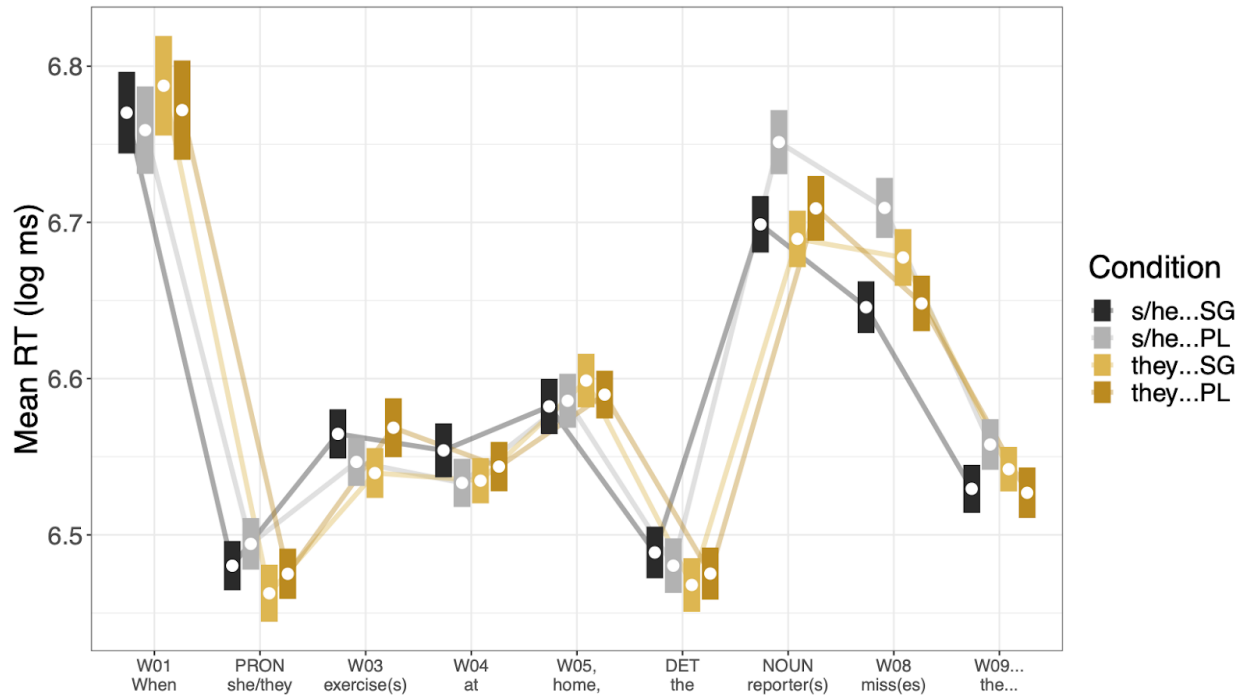
Figure 2: Word-by-word L-Maze reaction times. White dots are means; bars indicate ± one standard error, calculated by participant.
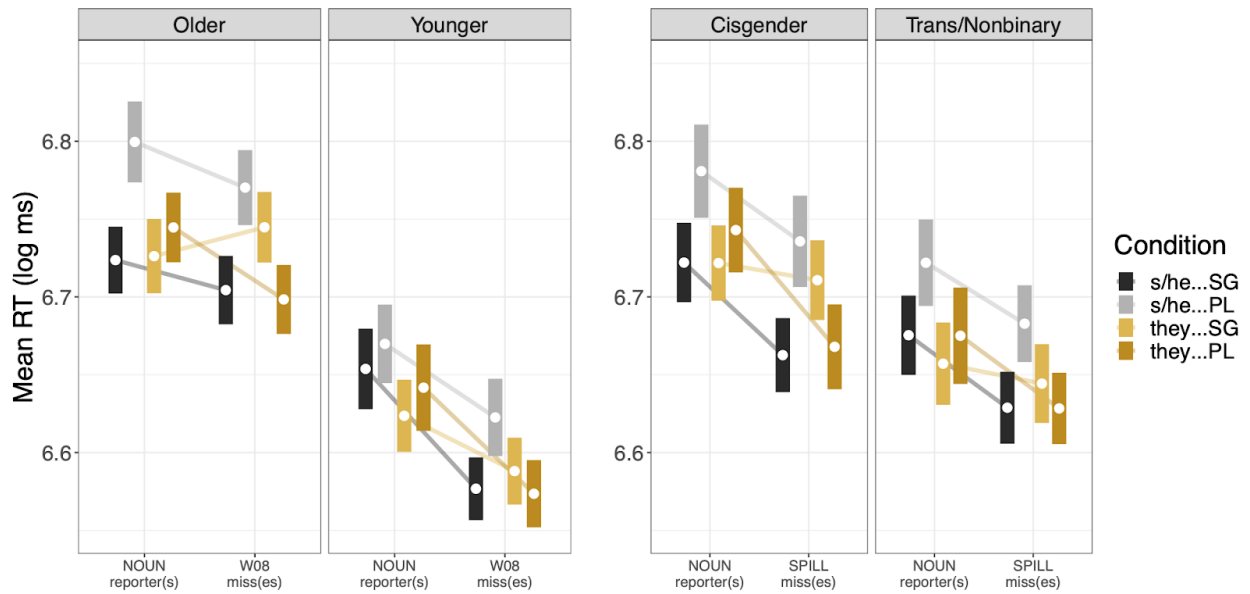

Figure 3: L-Maze reaction times at the critical matrix-subject noun and spillover regions. White dots are means; bars indicate ± one standard error, calculated by participant.

Results of linear models are reported in the following tables. First, consider the models using age as a fixed effect (Table 2). At the noun region, they find significant main effects of cataphor (conditions with cataphoric *s/he* read more slowly), of age (older participants reading more slowly), and a cataphor–match interaction (*s/he…PL* contributing disproportionately to slowdowns). At the spillover region, they find main effects of number match (mismatched conditions read more slowly), age (older participants reading more slowly), and the same cataphor–match interaction.

	Noun region LogRT ~ Cataphor*Match*Age + (1+Match|Participant) + (1|Item)				**Spillover region** LogRT ~ Cataphor*Match*Age + (1+Cataphor|Participant) + (1|Item)			
	Est.	**SE**	*t* **(df)**	*p*	**Est.**	**SE**	*t* **(df)**	*p*
(Int.)	6.7	0.024	270 (81)	< 0.001 ***	6.6	0.025	250 (56)	< 0.001 ***
Cataphor	−0.022	0.0094	−2.3 (3100)	0.019 *	−0.013	0.0097	−1.4 (110)	0.15
Match	0.017	0.0099	1.7 (110)	0.077	0.046	0.0095	4.8 (3100)	< 0.001 ***
Age	0.10	0.033	3.0 (110)	0.0030 *	0.14	0.028	5.0 (110)	< 0.001 ***
Cat:Mat	−0.068	0.018	−3.6 (3100)	< 0.001 ***	−0.038	0.019	−2.0 (3100)	0.043 *
Cat:Age	−0.022	0.018	−1.1 (3200)	0.24	−0.011	0.019	−0.56 (110)	0.57
Mat:Age	0.027	0.019	1.3 (110)	0.17	0.029	0.019	1.5 (3100)	0.11
C:M:A	−0.027	0.038	−0.70 (3100)	0.48	−0.048	0.039	−1.2 (3100)	0.21

Table 2: Results of linear mixed-effect modeling of log RTs at critical regions, with age-bracket as a fixed effect. Random-effects structure shown in *lmer* syntax.

Next, the models with gender orientation as a fixed effect (Table 3). At the noun, they find a significant main effect of cataphor (*s/he* conditions read more slowly) and a cataphor–match interaction (the *s/he…PL* condition contributing disproportionately to the slowdown). At the spillover region, there is a significant main effect of match (mismatched conditions read more slowly), and the same cataphor–match interaction.

	Noun region LogRT ~ Cataphor*Match*Gender + (1+Match|Participant) + (1|Item)				**Spillover region** LogRT ~ Cataphor*Match*Gender + (1+Cataphor|Participant) + (1|Item)			
	Est.	**SE**	***t* (df)**	***p***	**Est.**	**SE**	***t* (df)**	***p***
(Int.)	6.7	0.025	260 (83)	< 0.001 ***	6.6	0.026	250 (62)	< 0.001 ***
Cataphor	−0.023	0.0093	−2.5 (3200)	0.011 *	−0.014	0.0097	−1.4 (110)	0.13
Match	0.018	0.0099	1.8 (110)	0.062	0.046	0.0094	4.9 (3100)	< 0.001 ***
Gender	0.059	0.034	1.6 (110)	0.092	0.052	0.031	1.6 (110)	0.099
Cat:Mat	−0.068	0.018	−3.6 (3200)	< 0.001 ***	−0.042	0.018	−2.2 (3100)	0.025 *
Cat:Gen	0.024	0.019	1.2 (3300)	0.20	0.0040	0.019	0.20 (120)	0.83
Mat:Gen	0.0098	0.020	0.48 (110)	0.62	0.016	0.019	0.86 (3200)	0.38
C:M:G	−0.016	0.037	−0.30 (3200)	0.75	−0.0054	0.038	−0.14 (3100)	0.88

Table 3: Results of linear mixed-effect modeling of log RTs at critical regions, with gender orientation as a fixed effect. Random-effects structure shown in *lmer* syntax.

4. Discussion

There is clear evidence for a Number Mismatch Effect at the matrix-subject noun region in *s/he…PL* condition (9b; light grey in figures). This demonstrates that comprehenders, upon encountering a singular animate pronoun in a potentially cataphoric position, expect a singular postcedent in the closest position allowed by Condition C. The incompatibility of the plural noun of this condition is immediately recognized, and the processing cost necessary of this foiled expectation lingers into the next word region. Slightly elevated reading times of the plural noun in the *they…PL* condition (9d; dark gold) hint at a general processing cost of plural nouns, perhaps reflecting the cognitive effort involved in their morphological decomposition.

A parallel Number Mismatch Effect in the *they…SG* condition (9c; light gold) has clearly different properties. It does not emerge until the spillover region, and it is numerically smaller in magnitude than the *s/he…PL* mismatch effect. This accords with some previous studies on anaphora, where mismatches between morphosyntactic number of an antecedent noun and subsequent pronoun are registered with a delay and elicit smaller processing costs in *SG…they* configurations (Sanford & Filik 2007, Filik et al.

2008). This may reflect the possibility of split antecedence (3) or non-referential uses of *they* (8). It may also be that the formal representation of number contrasts contributes to this processing asymmetry. It has been argued that plurals are featurally and/or semantically underspecified (Sauerland et al. 2005; Sauerland 2008). If only singular pronouns have number features, perhaps cataphoric *s/he* forces comprehenders to commit to a particular abstract representation of its postcedent which is immediately recognizable as foiled by an featurally underspecified plural matrix subject. This representational approach helps explain some but not all phenomena in the processing of plural expressions (Patson 2014).

It is notable that previous studies on cataphora do not find such clearly asymmetrical Number Mismatch Effects. In Van Gompel & Liversedge's (2003, exp. 3) eyetracking experiment on English, the *they…SG* condition (5c) exhibited processing disruptions similar in timecourse and magnitude to the *s/he…PL* condition (5b). In Giskes & Kush's (2022) self-paced reading experiment on Dutch, the *Pronoun.PL…Verb.SG* condition (6c) causes processing difficulties as soon as the *Pronoun.SG…Verb.PL* (6b) — though their *SG…PL* mismatch effect does linger longer than the *PL…SG* one.

Why does the *they…SG* effect in the present study seem to be different? If the asymmetry simply reflects a semantic or morphosyntactic difference between singular and plural categories, we would expect it to manifest across languages and historical moments. One explanation has to do with the task: perhaps the L-Maze methodology localizes certain processing difficulties in unique ways; indeed, Maze variants have been shown to reduce spillover effects, compared to traditional self-paced reading techniques (Boyce et al. 2020). Another possible explanation is the participant population. Van Gompel & Liversedge recruited British undergraduates in the early 2000s; Giskes & Kush recruited self-reported native speakers of Dutch. We speculate that the state of contemporary American English specifically — exhibiting language change which is politically and culturally salient, even to speakers with non-innovative pronoun use — may be reflected in our participants' processing behavior: perhaps a baseline awareness of definite singular *they* has influenced the kinds of postcedents they might expect for potentially cataphoric *they*.

As for our demographic manipulations, visual inspection of *they…SG* vs. *s/he…PL* conditions suggests that younger and trans/nonbinary participants were less phased by singular postcedents to cataphoric *they* than older and cisgender participants were. This lends some support to our socio-psycholinguistic prediction that demographic variables associated with higher offline acceptability of definite singular *they* should also predict the real-time expectations about the possible number features of postcedents to potentially cataphoric *they*.

However, statistical tests did not find reliable interactions between the experiment's grammatical and demographic manipulations. (There was a main effect of age, reflecting a slower baseline reaction time among the older half of our participants — an unsurprising result not relevant to our hypotheses.) This may be a Type 2 error that could be resolved with a larger sample size. In any case, it shows that our very coarse-grained sociolinguistic design factors (age-bracket and gender binarity) are at best quite noisy predictors of individual variation in the processing of cataphoric dependencies involving *they*. Perhaps some of our cisgender participants were highly innovative pronoun users, highly conscientious of gender-neutral language; perhaps some of our trans/nonbinary participants had only recently transitioned, and are consequently less fluent users of definite singular *they*, due to limited exposure to and practice with it. Future work might untangle these possibilities by investing more fine-grained variables (including

gender and language ideology), or by integrating traditional variationist methodologies like sociolinguistic interviews.

5. Conclusion

A Lexicality Maze experiment, with participants representing a diverse range of ages and gender orientations, investigated links between sociolinguistic variation and the real-time processing of cataphoric dependencies. The sociolinguistic findings are modest, but even setting effects related to demographic manipulations aside, we find evidence of asymmetric Number Mismatch Effects which to our knowledge have not been previously noted in the psycholinguistic literature on cataphora.

Methodologically, our study is innovative in a few key ways. Experimental work on singular *they* has increased in recent years, but it has mostly focused on anaphora. By investigating cataphora instead, this study gives comprehenders time to dwell on possible interpretations of a pronoun, before having to evaluate them relative to the morphosyntactic and lexical-semantic properties of an R-expression supplying its referent. Cataphoric dependencies are also never obligatory (7), so the stimuli here pose less of a chance of exposing non-innovative users to referential dependencies which necessitate definite singular *they*.

Second, our study recruited equal numbers of cisgender and trans/nonbinary participants. Whether innovative pronoun use and comprehension is connected more to ideology — individuals' political views or epistemology of gender, say (Conrod 2022) — or to acquisition — the number of tokens of definite singular *they* they have heard and produced — it is bound to be those people with transgender, nonbinary, and other non-cisgender identities who are the most innovative on average. Therefore it behooves investigation of this particular domain of individual variation to actively recruit trans/nonbinary participants.

Finally, we note an important linguistic factor to investigate in future research. This study's design conflates the obviated (4b) and nonbinary (4c) definite-singular uses of *they*. Matrix-subject nouns were definite, but stimuli were presented out of the blue, without contexts that might support one or the other reading of singular *they*. And insofar as our participants had meaningful intuitions about what kinds of nouns (*reporter*, *senator*, *barista*, etc.) are likely to refer to nonbinary people, we did not attempt to control this when constructing stimuli. Previous work on singular *they* has noted higher acceptability when antecedents are definite nouns rather than names (Bjorkman 2017, Conrod 2019). Since obviated *they* is less innovative than nonbinary *they*, this is unsurprising: for many people, it is easier to imagine a context where the gender of a referent like *the reporter* (who may in fact be cisgender) is irrelevant or unknown, than it is to imagine a context where that is the case for someone referred to by a proper name. In contrast, a proper name anteceding *they* is much more likely to suggest the individual is nonbinary, than it is that their gender is contextually obviated. How different types of definite singular *they* are comprehended is an important theoretical question, one we leave to future socio-psycholinguistic work.

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