Syntactic Memory in the Comprehension of Reflexive Dependencies: an Overview

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Abstract

The distribution of reflexive anaphors has long been of central importance in the development of syntactic theory. In a parallel fashion, research on the comprehension of reflexive anaphors is increasingly influential for theories of syntactic comprehension. In this article, I present the problem of selecting a reflexive’s antecedent as a memory retrieval problem and illustrate why the comprehension of reflexives is of special interest for theories of the memory architecture of the sentence processor. I review a range of influential findings on reflexive comprehension, focusing on results that concern the speed and grammatical accuracy of antecedent retrieval. An emerging empirical generalization is that reflexives are relatively immune to retrieval interference, a property that sets them apart from superficially similar syntactic dependencies like subject–verb agreement. Existing data, across languages and across methodologies, suggest that comprehenders retrieve a reflexive’s antecedent primarily on the basis of its syntactic position.

Interpreting Reflexive Dependencies: a Question of Memory

Reflexive anaphors are pronominal elements whose antecedent is canonically found in their local clause. (1) Provides an example (identical subscripts indicate coreference).

(1) At Mary’s party, John disguised himself

In (1), the antecedent of the reflexive himself must be the local subject John, the only antecedent that is syntactically accessible. Investigation into such constraints on anaphoric reference – binding theory – has been a driving force in the development of syntactic theory and has provided significant insight into the organization of grammar (Chomsky 1981). Similarly, psycholinguists have often studied how pronouns achieve reference with their antecedents to address questions about the online encoding and manipulation of linguistic representations (for overviews, see Sanford and Garrod 1989; Nicol and Swinney 2003; Sturt 2013). The present review focuses on how reflexive anaphors, in particular, can shed light on how comprehenders organize and access linguistic encodings during comprehension. There are three parts to this review. In the first, I briefly review the constraints that hold of reflexive pronouns. In the second, I cast the problem of reflexive comprehension as a memory search problem, with reference to contemporary models of working memory in sentence processing. Against this theoretical backdrop, I then present a range of experimental findings on the processing of reflexives and discuss the implications for theories of the memory architecture of the sentence processor.

Constraining Anaphoric Reference

Diverse theoretical accounts of the licensing constraints on reflexives seek to capture one core generalization: reflexive anaphors are licensed when their antecedent is in a structurally
prominent position in a sufficiently local domain. However, theories differ greatly with respect to how they define structural accessibility and how they define a local domain. Perhaps the most well-known principle proposed to account for the interpretation of reflexives is Chomsky’s Principle A (Chomsky 1981), which states that reflexives must be bound (a condition on the structural prominence of the antecedent) within their governing category (a locality condition).

The examples in (2) illustrate the role that locality and syntactic prominence play in licensing reflexives. An example like (2a) is ungrammatical because the antecedent *John* is too structurally distant from the reflexive, and in (2b), *John* is not structurally prominent enough to anteced the reflexive.

(2) a. *John* thinks Mary disguised himself.
   b. [A friend of [John]] disguised himself

Generative approaches to this prominence condition have used a phrase-structural notion of command to define prominence (Langacker 1969; Jackendoff 1972; Chomsky 1981). The most widely known variant of such a command relation is Reinhart’s c(onstituent)-command (Reinhart 1976, 1983), defined as follows:

(3) c-command: A c-commands B iff neither A nor B dominates the other, and the first branching node dominating A also dominates B. (Reinhart 1983, pp. 18)

In the parse illustrated in Figure 1, the NP *A friend of John* c-commands the reflexive, and *John* does not. An antecedent is said to bind the reflexive when it corefers with and c-commands the reflexive. On this definition, *John* cannot bind the reflexive in (2b) and so cannot serve as its antecedent. Alternative theories state the prominence condition on antecedents more directly over the coargument relations in the predicate that hosts the reflexive. For example, Pollard and Sag (1992) claim that structural prominence is determined on a scale of obliqueness relations over a list of the syntactic arguments of a predicate (see related ideas in Jackendoff 1992; Van Valin and LaPolla 1997). However, all theories maintain that structural prominence is a relative notion: binding may occur if an antecedent’s structural position is prominent relative to the position of the reflexive.

In addition to a prominence condition, reflexives must be bound in some local domain. Under Principle A, the relevant local domain is the governing category, a phrase-structural notion that roughly captures the local clause or noun phrase containing the reflexive and an accessible SUBJECT (a technical term that encompasses subjects as well as NP possessors). Other approaches, such as Reinhart and Reuland (1993), eschew tree-geometric approaches of this sort in favor of stating the locality domain in terms of the syntactic predicates (see also Pollard and Sag 1992).
Much remains to be learned about the constraints that hold of reflexive anaphors across languages and across syntactic configurations. Already, numerous exceptions to the most rigid formulation of the binding principles have been observed. For instance, structural constraints such as Principle A seem to be weakened when a reflexive and its antecedent are not coarguments of a predicate, leading some researchers to posit a distinct class of non-coargument reflexives known as exempt anaphors (Pollard and Sag 1992) or logophors (Reinhart and Reuland 1993). It is thought that these reflexives are constrained not just by syntax but also by discourse factors such as point of view or source of communication (Kaiser et al. 2009; Kuno 1972; Pollard and Sag 1992; Reinhart and Reuland 1993; Runner et al. 2003, 2006; Sells 1987). There is also significant cross-linguistic variation in the binding constraints. In particular, Principle A, as formulated above, does not obviously apply to languages that have long-distance reflexives, reflexives that may be bound by syntactically prominent antecedents outside of their local clause. For a review of cross-linguistic variation in potential binding domains, see Büring (2005) and Cole et al. (2001).

In comprehension, the grammatical constraints on reflexives may serve to limit the antecedent search space to a few structurally accessible positions. As I argue below, it is natural to implement these constraints as a memory search procedure in comprehension. However, the same reasoning does not obviously apply to the binding constraints on non-reflexive pronouns. Principle B of the binding theory constrains the interpretation of pronouns, requiring that a pronoun be free (i.e. not bound) in its local binding domain (Chomsky 1981). Rather than ruling in antecedents in particular syntactic positions, as Principle A does, Principle B might be said to rule out those same structurally prominent antecedents for pronouns. Indeed, the largely complementary distribution between pronouns and reflexives implied by this description is an empirical generalization that is at the core of the classical binding theory. As Principle B excludes, rather than includes, potential antecedents, one might question whether it is evaluated during online comprehension in the same manner as Principle A. I do not attempt to answer this question here, and so for the moment, leave aside the issue of how binding constraints on non-reflexive pronouns are evaluated in comprehension (but see Badecker and Straub 2002; Kush 2013; Nicol and Swinney 1989, 2003; Sturt 2013).

Anaphoric Reference and Memory Search

Much research has been devoted to asking whether binding constraints like Principle A are implemented as early filters on the process of generating a set of candidate antecedents for an anaphoric expression (Badecker and Straub 2002; Nicol 1988; Nicol and Swinney 1989; Sturt 2003a,b). Here, I pose this question as a question of memory search: when searching for a reflexive’s antecedent, do comprehenders limit their search only to syntactically licensed antecedent positions? Put this way, reflexives are of significant interest for researchers interested in the memory architecture of the sentence processor. If antecedent selection involves memory access, then we must provide answers to at least the following two questions:

i) What is the status of potential antecedents prior to encountering a reflexive?

ii) If comprehenders must retrieve an antecedent, how is that retrieval executed?

Although cast as questions about reflexive comprehension, these are instantiations of broader theoretical questions about the use of working memory during sentence comprehension.
Theories of referential processing commonly distinguish between active and passive maintenance of antecedent representations. On active maintenance models, possible antecedents are maintained in an active state or buffer, and pronominal reference is achieved by linking pronouns to antecedents that are highly available or attended to in this way (Chafe 1974; Greene et al. 1992; Gundel 1999; Karmiloff-Smith 1980). Borrowing terminology from the working memory literature, we may say that such accounts maintain possible antecedents in focal attention (McElree 2001, 2006; McElree and Dosher 1989; McElree et al. 2003; Oberauer and Hein 2012).

However, it is generally thought that there is some bound on the information that may be actively maintained in focal attention (Broadbent 1958; Cowan 1995, 2001; McElree and Dosher 1989; McElree 2001, 2006; Oberauer and Hein 2012). Because of this, participants may be forced to store potential antecedents in a non-attended or passive state, freeing up resources to attend to other processing tasks that intervene between an antecedent and an anaphor. By hypothesis, passively maintained antecedents must be restored to focal attention (retrieved) to participate in referential dependencies. A number of researchers have suggested that pronouns constitute an explicit instruction for the processor to retrieve a passively maintained antecedent from memory (Corbett and Chang 1983; Gernsbacher 1989; Kaiser 2003; Foraker and McElree 2007).

There is solid empirical support for the view that a reflexive’s antecedent is not actively maintained but rather that it is passively stored and retrieved at the reflexive. In an early study, Nicol (1988) presented sentences like the following to participants:

(4) The boxer told the skier that the doctor for the team would blame him/himself * for the injury.

Nicol used a cross-modal lexical priming (CMLP) paradigm to test for priming of semantic associates of boxer, skier, and doctor. While listening to sentences as in (4), participants were given a visual lexical decision task at the point indicated by the asterisk. When the anaphor was a pronoun, Nicol observed priming to associates of boxer and skier. However, when the pronoun was a reflexive, only associates of doctor (e.g. nurse) were primed. Importantly, when the lexical decision probe precedes the anaphor, no such activation is found (Nicol and Swinney 1989; Osterhout and Swinney 1993). On the assumption that semantic priming tracks the activation of antecedent representations, this result suggests that comprehenders do not actively maintain potential antecedents prior to the reflexive. Instead, it seems that antecedent representations are retrieved only when comprehenders assign reference to an anaphor. Similar results using a probe recognition paradigm have been observed for long-distance reflexives in Mandarin Chinese (Gao et al. 2005; Liu 2009).

Online eye-tracking measures provide a second measure of evidence in support of the claim that a reflexive must retrieve its antecedent. The visual world eye-tracking results of Runner and colleagues (2003, 2006) showed that comprehenders looked to the antecedent of a reflexive at the offset of the anaphor but not before (see also Clackson et al. 2011; Kaiser et al. 2009). Similar reactivation profiles have also been observed for long-distance reflexives in Korean (Han et al. 2010). However, the need to reactivate an antecedent may vary as a function of syntactic environment: in Kaiser et al. (2009)’s experiment 3, it appears that comprehenders may retain an active focus on a possessor argument (e.g. Bill in Bill’s picture of himself) throughout the comprehension of the picture NP.
If processing a reflexive involves retrieval of an antecedent from a passive state, the question arises of how this retrieval proceeds. Here are at least two distinct sub-questions that any model of antecedent retrieval must answer: what information guides retrieval and what is the mechanism by which the retrieval is executed?

One possible answer to the first sub-question is that all sources of linguistic information may interact during retrieval. This view is similar to claims that the initial set of candidate antecedents is defined by all antecedents that match the morphosyntactic and discourse constraints on the reflexive (Badecker and Straub 2002; Kaiser 2003; Kaiser et al. 2009). Another possibility is that only a restricted subset of information is used to guide retrieval. Nicol (1988) and Sturt (2003a,b) proposed that syntactic binding constraints are used as a filter in the early stages of antecedent selection and that other constraints were evaluated subsequent to the application of binding theory. Dillon et al. (2013) argued that binding theory served to filter antecedent selection through a memory retrieval process that limited retrieval to structurally licensed antecedent positions (so-called structured access).

The second sub-question concerns the retrieval mechanism. There are at least two classes of candidate mechanism (McElree et al. 2003): cue-based direct-access retrieval or search mechanisms. Cue-based direct-access models access stored representations by matching a set of features (cues) against the contents of working memory. The representation that best matches those cues is then retrieved and restored to focal attention. Retrieval is content-addressable: representations are retrieved based on their content rather than their position in memory. Alternatively, stored representations may be retrieved with a search mechanism. Search mechanisms retrieve representations based on their location in memory and may be implemented using either serial or parallel comparison processes over some positionally defined search set (see Townsend and Ashby 1983).

Direct-access retrieval and search mechanisms make distinct predictions about the time course of memory access and what representations will cause interference. The signature prediction of direct-access retrieval models is that the time needed to retrieve a representation does not grow as the search space grows. Instead, representations that match the retrieval cues are always retrieved in constant time even if they differ in the strength or quality of encoding (McElree and Dosher 1989; McElree et al. 2003; McElree 2006). In contrast, search mechanisms generally predict that access times should grow with the search set. Retrieval mechanisms may also be distinguished with respect to the phenomenon of retrieval interference. In a content-addressable architecture, any representation that overlaps with the retrieval cues may contribute to retrieval interference. To the extent that search mechanisms predict such interference at all, it should arise only from representations in a positionally defined search set.

There is growing evidence that a number of long-distance dependencies are susceptible to retrieval interference from syntactically inaccessible representations, suggesting that the parser does recruit the use of a cue-based retrieval mechanism during the construction of some linguistic dependencies (Lewis and Vasishth 2005; Lewis et al. 2006; Van Dyke and Johns 2012). Dependencies that are susceptible to retrieval interference include subject–verb thematic dependencies (Van Dyke and Lewis 2003; Van Dyke 2007; Van Dyke and McElree 2011), subject–verb agreement (Pearlmutter et al. 1999; Wagers et al. 2009), filler-gap dependencies (Gordon et al. 2001, 2006; Van Dyke and McElree 2006), and negative polarity item dependencies (Vasishth et al. 2008; Xiang et al. 2009). For instance, Wagers et al. (2009) argue that agreement attraction effects – the ability of syntactically unavailable NPs to control verbal agreement, as in *? the key to the cabinets are rusty...
(Bock and Miller 1991) – are a reflection of cue-based retrieval interference. Specifically, these authors claim that number is used as a cue to retrieve a nominal head to license agreement morphology on the verb and that agreement attraction results when the number features of the local noun are incorrectly retrieved.

Time course data also implicate the use of a cue-based retrieval mechanism during sentence comprehension. Questions of time course have primarily been studied using the speed-accuracy trade-off (SAT) technique, which allows for direct modeling of the time course of retrieval (see McElree 2006). SAT data suggest that the size of the search set does not in general impact the speed with which comprehenders retrieve syntactic dependents for a number of linguistic dependencies: cross-sentential anaphora (Foraker and McElree 2007), VP ellipsis (Martin and McElree 2008), subject–verb integration (McElree 2000; McElree et al. 2003; Van Dyke and McElree 2011), filler-gap dependencies (McElree et al. 2003), and sluicing (Martin and McElree 2011). These results provide further support for the use of a direct-access, cue-based retrieval mechanism during sentence comprehension.

Against this background, the processing of antecedent-reflexive dependencies takes on particular interest. As I document below, current empirical evidence suggests that the construction of reflexive dependencies is relatively immune from retrieval interference, and what little time course data there is suggests that antecedent retrieval may not have the direct-access property observed for other dependencies. These data raise interesting questions of how and why memory access should vary across different linguistic dependencies and what conclusions this licenses about the memory architecture of the sentence processor.

**Antecedent Retrieval: Empirical Evidence**

**RETRIEVAL INTERFERENCE**

Evidence for Grammatically Accurate Retrieval

Nicol (1988) was the first to ask whether comprehenders immediately applied the binding principles to restrict the set of candidate antecedents when processing a reflexive (Nicol 1993; Nicol and Swinney 1989; see also Sturt 2003a,b; Runner et al. 2006). In the present context, we may cast her question in terms of retrieval interference: is antecedent retrieval limited only to grammatically licensed antecedent positions or do syntactically inaccessible antecedents interfere with retrieval? On the basis of the CMLP studies discussed above, Nicol (1988) and Nicol and Swinney (1989) concluded that there was no interference from inaccessible antecedents.

Since Nicol’s original findings, a number of other studies have corroborated this conclusion. Important evidence in favor of this conclusion comes from experimental paradigms that explicitly manipulate the degree of interference from inaccessible antecedents. In a widely-cited paper, Sturt (2003a) used eye-tracking while reading to investigate short discourses as in (5) (Experiment 1) and (6) (Experiment 2):

(5) Jonathan was pretty worried at the City Hospital.
   a. He remembered that the surgeon had pricked himself with a needle.
   b. #He remembered that the surgeon had pricked herself with a needle.

(6) Jennifer was pretty worried at the City Hospital
   c. She remembered that the surgeon had pricked himself with a needle.
   d. #She remembered that the surgeon had pricked herself with a needle.
Jonathan was pretty worried at the City Hospital.

a. The surgeon who treated Jonathan had pricked himself with a needle.

b. #The surgeon who treated Jonathan had pricked herself with a needle.

Jennifer was pretty worried at the City Hospital

c. The surgeon who treated Jennifer had pricked himself with a needle.

d. #The surgeon who treated Jennifer had pricked herself with a needle.

The grammatically licit antecedent the surgeon was always associated with a strong gender stereotype. Previous research has shown that comprehenders initially treat violations of these stereotypes (marked here with #) as ungrammatical (Osterhout et al. 1997). In addition to manipulating the perceived gender match with the accessible antecedent, Sturt also manipulated the gender of the inaccessible antecedent (he/Jonathan). In both Experiments 1 and 2, the only main effect that Sturt found was an effect of gender match for the grammatically licit antecedent, reflecting early detection of the anomaly. The gender of the inaccessible antecedent did not effect early reading times at the reflexive. This suggests that retrieval was effectively blind to the feature content of the inaccessible antecedents. Re-reading times in Experiment 1 did reveal an effect of gender match for the inaccessible antecedent, however: reading times were faster for the multiple match condition (5a) than for (5c). However, the interference pattern did not replicate in Experiment 2, and in fact, the numerical trend of the pattern was reversed. Subsequent studies have extended and confirmed the non-interference effect observed by Sturt. In their native speaker control group, Felser et al. (2009) replicated the non-interference effect for sentences like (5) and further observed that inaccessible experiencer arguments of raising predicates do not lead to interference at the reflexive. Likewise, Felser and Cunnings (2012) observed no early interference for sentences like (5) with their English native speaker control groups, although they did observe an effect of the inaccessible antecedent in sentences like (6): reading time on (6a) was faster than (6b), and (6d) faster than (6c), in gaze duration and go-past measures.

Other studies report similar results. Clifton et al. (1999) reported two self-paced reading experiments that looked at the impact of inaccessible antecedents on the processing of reflexives in sentences like the following:

(7) a. The waitress (with the handsome friend) burned herself after spilling the soup.

b. The son (of the fireman) hurt himself in a bad accident.

Both experiments showed that comprehenders read the reflexive region more slowly when the subject was complex, but this pattern was also seen in control conditions that had a lexical object in place of a reflexive. Because the presence of a reflexive did not interact with the presence of an inaccessible antecedent inside the subject NP, these data suggest that the search set for a reflexive effectively includes only the grammatically licit subject NP. In another paper that used self-paced reading, Badecker and Straub (2002) failed to find interference effects from genitive possessor NPs (Experiment 5) or experiencer arguments of raising predicates (Experiment 6).

Xiang et al. (2009) investigated the sentences in (8) in an ERP experiment.

(8) a. Congruent: The tough soldier that Fred treated in the military hospital introduced himself to all the nurses.

b. Intrusive: The tough soldier that Katie treated in the military hospital introduced herself to all the nurses.

c. Incongruent: The tough soldier that Fred treated in the military hospital introduced herself to all the nurses.
As in previous work (Osterhout et al. 1997), they observed a P600 effect (an ERP component associated with the detection of grammatical anomalies) at the reflexive in (8b) and (8c). This confirms that comprehenders immediately perceive the reflexive as grammatically anomalous given the gender stereotypes associated with soldier. If comprehenders erroneously retrieved the inaccessible antecedent Katie at the reflexive, then the magnitude of the P600 should have decreased in this condition, reflecting spurious licensing of the apparently illicit reflexive. However, the magnitude and timing of the P600 was identical in conditions with a gender-matched inaccessible antecedent (8b). These results provide further evidence that inaccessible antecedents are not retrieved while processing a reflexive. Importantly, the lack of retrieval interference for reflexive dependencies in Xiang et al.’s experiment stood in contrast to a clear pattern of retrieval interference observed in a paired ERP experiment, suggesting substantial differences in the retrieval processes used to license each dependency.

Interestingly, the grammatically accurate retrieval profile associated with reflexives contrasts with other syntactic dependencies that differ only minimally from reflexive-antecedent dependencies. Dillon et al. (2013) directly compared the processing of reflexive dependencies to subject–verb agreement dependencies in English, using materials as in (9):

(9) a. The new executive who oversaw the middle manager(s) apparently doubted himself/*themselves on most major decisions.

b. The new executive who oversaw the middle manager(s) apparently was/were dishonest about the company’s profits.

Using eye-tracking, Dillon and colleagues observed agreement attraction in structures like (9b): comprehenders showed eased processing of the ungrammatical verb form were when the structurally illicit NP middle manager(s) was plural compared to when it was singular. This pattern suggests that comprehenders failed to detect ungrammatical agreement dependencies (a so-called illusion of grammaticality) in the presence of a feature-matched distractor NP. Dillon and colleagues argued that this pattern provides critical evidence that comprehenders had misretrieved the inaccessible NP middle managers and used its feature values to license the agreement on the verb. In contrast, there was no interference from the inaccessible NP for minimally different reflexive dependencies, as in (9a). The contrast between agreement and reflexives is striking, as the retrieval necessary to license both agreement and reflexive dependencies must access the same subject position.

Given the central role that coargumenthood plays in some theoretical accounts of reflexives (Pollard and Sag 1992; Reinhart and Reuland 1993), one might wonder if the lack of retrieval interference observed in these studies reflects the fact that the reflexive and its antecedent were almost always coarguments of the same predicate. To test this possibility, Cunnings and Sturt (2012) used examples like (5) with picture noun phrase (PNP) reflexives both with and without a possessor (e.g. a/Bill’s picture of himself). In possessorless PNP constructions, the reflexive and its antecedent are not coarguments of the same predicate. Using eye-tracking while reading, they replicated Sturt’s (2003a) findings: there was no effect of interference on these reflexives from grammatically inaccessible antecedents. Thus, it appears that coargumenthood is not a precondition for grammatically accurate retrieval.

Similar results were found by Clackson et al. (2011), who looked at the processing of benefactive reflexives. In sentences like (10), Clackson and colleagues tested for interference from the subject of the main clause predicate (which also served as the topic of the mini-discourse):
In an offline picture interpretation experiment, Clackson and colleagues found that adult participants uniformly chose the local subject Mr. Jones as the antecedent for the reflexive. In a visual world experiment, adults showed no significant increase in looks to the inaccessible antecedent in the double match condition relative to the single match condition. Thus, even when the reflexive was not an obligatory coargument of its antecedent, Clackson and colleagues still failed to observe interference from inaccessible antecedents.

Evidence for Retrieval Interference

Despite much evidence that suggests comprehenders are grammatically accurate when retrieving a reflexive’s antecedent, there is some evidence of interference from inaccessible antecedents. Using self-paced reading, Badecker and Straub (2002) examined the processing of reflexives (11) and reciprocal anaphors such as each other (12):

(11) a. Single match: Jane thought that Bill owed himself another opportunity to solve the problem.
   b. Double match: John thought that Bill owed himself another opportunity to solve the problem.

(12) a. Single match: The attorney thought that the judges were telling each other which defendants had appeared as witnesses before.
   b. Double match: The attorneys thought that the judges were telling each other which defendants had appeared as witnesses before.

In (11), Badecker and Straub found increased reading times at the reflexive in the double match condition relative to the single match condition (a multiple match effect). In the reciprocal conditions, they also found a multiple match effect, though the effect was somewhat weaker. In an eye-tracking experiment with conditions similar to those in Xiang et al. (2009) and Sturt (2003a), Patil et al. (2011) also found evidence for a multiple match effect. Chen et al. (2012) used SPR to investigate the comprehension of the Mandarin Chinese long-distance reflexive ziji and found evidence for a multiple match effect when inaccessible antecedents matched the accessible antecedent on animacy features. However, such multiple match effects are not observed consistently. Most studies reported above find no effect of the inaccessible antecedent, and others report that multiple feature-matched antecedents leads to a processing speed-up, rather than a slowdown (in late eye-tracking measures: Sturt 2003a; in early eye-tracking measures, Felser and Cunnings 2012).

Across different reading studies that have looked at interference effects, interference has been argued to underlie both reading time speed-ups (NPIs: Vaisishth et al. 2008; subject–verb agreement: Pearlmutter et al. 1999; Wagers et al. 2009) and slowdowns (S–V thematic integration: Van Dyke and Lewis 2003; Van Dyke 2007; Gap–filler integration: Gordon et al. 2001, 2006; Van Dyke and McElree 2006). In light of this variation, care is required in the interpretation of any given effect. Based on simulation results, Dillon et al. (2013) argued that only reading time facilitation provides unambiguous evidence for misretrieval of syntactically inaccessible heads. This facilitation has been referred to as an illusion of grammaticality (Phillips et al. 2011), because this pattern is thought to arise when the features of an inaccessible head are erroneously accessed, resulting in the spurious licensing of what would otherwise be an unlicensed element. Dillon and colleagues argue that the interpretation of multiple match slowdowns is less clear. They suggest that multiple match effects could reflect encoding interference, rather than retrieval interference, possibly due to feature-overwriting.
mechanisms that degrade the fidelity of highly similar representations in working memory (Nairne 1990; Oberauer and Kliegl 2006; but c.f. Van Dyke and McElree 2006). However, recent work by Jäger et al. (2013) casts doubt on this interpretation of the multiple match effect. Jäger et al. investigated the processing of the German reflexive sich, which is not morphologically marked for gender or number. If multiple match effects reflect encoding interference, Jäger et al. reasoned, then multiple match interference effects should be observed for sich even though it has no gender feature to use as a retrieval cue. However, in a pair of high-powered studies using eye-tracking and SPR, Jäger and colleagues failed to observe any multiple match effect for sich. These results suggest that to the extent that multiple match effects are observed in English, they should be attributed to retrieval interference. However, this finding leaves open the critical question of why multiple match effects are only rarely observed for reflexives and, in at least some cases, significantly reversed.

At least one experiment does report an illusion of grammaticality effect for reflexives, however. King et al. (2012) investigated sentences as in (13):

\begin{itemize}
  \item \textbf{Adjacent:} The bricklayer who employed Gregory/Helen shipped himself/herself sacks of mortar…
  \item \textbf{Non-adjacent:} The bricklayer who employed Gregory/Helen shipped sacks of mortar to himself/herself…
\end{itemize}

King and colleagues hypothesized that grammatically accurate retrieval occurs when the reflexive is linearly adjacent to the predicate and so potentially coactive in focal attention with the subject. Using self-paced reading and eye-tracking, they replicated the grammatically accurate retrieval profile for reflexives that were adjacent to the verb. However, when the reflexive was separated from the predicate as in (13b), eye-tracking measures showed an illusion of grammaticality effect when the inaccessible antecedent matched the features of the reflexive. In an SPR experiment with the same materials, however, they observed no illusion of grammaticality. King et al. suggest that the local subject may be maintained in focal attention across a verb, obviating the need for the comprehender to execute an interference-prone retrieval at the reflexive. However, many questions remain about the generality of this predicate adjacency effect, as a number of other studies have reported interference-free retrieval for reflexives in non-adjacent positions (Clackson et al. 2011; Cunnings and Sturt 2012). In addition, King et al.’s account of their data contrasts with Nicol and Swinney’s (1989) CMLP studies, which suggested that the local subject is not maintained in focal attention prior to the reflexive.

Interference from inaccessible antecedents also arises under conditions where one might expect comprehenders to have difficulty in recovering a reliable parse of the input. Nicol (1993; reported in Nicol and Swinney 2003) reports a replication of her original studies using RSVP rather than auditory presentation. In contrast to the CMLP studies, she found that in the visual modality, comprehenders reactivated the linearly closest antecedent at the reflexive, even if it was not grammatically licit. She suggested that the demanding RSVP presentation made it difficult for readers to develop fully articulated syntactic representations, and so they could not use a syntactic parse to support accurate retrieval of an antecedent.

Similarly, for populations who may have difficulty constructing syntactic parses online, there is evidence for interference from inaccessible antecedents in comprehension. Clackson et al. (2011) compared the performance of children, aged 6 to 9, to adults. Although the children mastered the binding principles in offline tests, in Clackson et al.’s visual world task, children showed a significant increase in looks to the inaccessible antecedent in double match conditions (\textit{Peter} in (10a)). Felser et al. (2009) and Felser and Cunnings (2012) found that Japanese and German learners of English were more susceptible to interference from
inaccessible antecedents than were English native speakers, despite the L2 learners’ offline mastery of the correct binding constraints for English. One exception is Choy and Thompson (2010), who found that agrammatic aphasics did not show interference in online comprehension, despite having poor offline comprehension.

Individual variation in processing ability seems to play a role, as well. Cunnings and Felser (2013) used stimuli like those in (5) and (6) to test whether grammatical accuracy in retrieval was related to working memory span. They used the reading span test of Daneman and Carpenter (1980) to group participants into low WM and high WM groups. When the inaccessible antecedent did not linearly intervene between the reflexive and its antecedent, as in (5), they found no retrieval interference for either WM group. However, in instances where the inaccessible antecedent linearly intervened between the reflexive and its true antecedent (6), there was a significant interaction of group by interference. This interaction was driven by increased reading times for sentences like (6c) relative to (6a). This pattern suggests that low WM readers initially retrieved the linearly closest NP and were subsequently surprised when its gender features did not match the reflexive. There was no effect of interference for the high WM group.

Lastly, in cases where the grammatical constraints on reflexives are subject to debate, it can be difficult to tease apart the effects of retrieval interference from inappropriately characterized grammatical constraints. For instance, Runner et al. (2003, 2006) report visual world data on the processing of possessed picture noun phrase (PPNP) reflexives. They monitored the eye movements of participants across a visual display when given instructions such as the following:

(14) Pick up Joe. Look at Ken. Have Joe touch Harry’s picture of himself.

Based on offline judgments, Runner and colleagues argued that *himself* in the PPNP context is an exempt anaphor that may be bound by either the possessor *Harry* or the local subject *Joe* (contrary to the standard view Chomsky 1986; Reinhart and Reuland 1993). Consistent with this analysis, they found early looks to both the possessor and the local subject in (14), but no increased looks to the unavailable lead-in antecedent *Ken* (although note that in similar configurations tested by Kaiser et al. (2009), very few looks to the subject were observed). If antecedent retrieval is limited to grammatically licensed positions, then we may conclude with Runner and colleagues that the grammatical constraints on PPNP reflexives have been mischaracterized. However, if one maintains the standard view that only the possessor argument is a syntactically accessible antecedent in (14), then one may model this finding as the result of retrieval interference from the inaccessible subject argument. It has been argued that this sort of ‘performance’ factor can have stable, long-lasting effects on binding judgments (Pollard and Sag 1992; but c.f. Asudeh 2000), and so further work may be necessary to partial out the effects of grammatical constraints from retrieval processes in cases where the grammatical constraints are less well understood.

TIME COURSE AND LOCALITY EFFECTS

Locality effects and the time course of antecedent retrieval constitute a second piece of empirical evidence that is useful for distinguishing between hypotheses about the retrieval mechanism that supports reflexive comprehension. There is relatively little evidence on this point, and much of the evidence for the time course of antecedent retrieval for reflexives is only indirect. Research on long-distance reflexives in Mandarin suggests that local dependencies are processed more quickly and with less effort than long-distance dependencies (Dillon et al. 2010; Gao et al. 2005; Liu 2009; Li and Zhou 2010). For instance,
Dillon and colleagues used the speed-accuracy trade-off technique and found that local construals of the Mandarin long-distance reflexive ziji were processed more quickly when the antecedent was in the local clause compared to when the antecedent was in a more distant clause. Similar results have been observed for probe recognition studies. Gao and colleagues (2005) and Liu (2009) observed activation of local antecedents at short SOAs following the presentation of ziji and activation of more distant antecedents only at longer SOAs. Li and Zhou (2010) present ERP evidence that comprehenders retrieve an antecedent in the local clause more easily than an antecedent in a non-local clause.

In languages like English, locality effects are more elusive due to the strictly local nature of reflexive binding. However, a number of studies investigated the processing of logophors, which typically are more structurally distant from their antecedents than are coargument reflexives. The processing of logophors appears to be more effortful or delayed relative to that of coargument reflexives (Burkhardt 2005; Harris et al. 2000; Koornneef 2008). Foraker (2003) found self-paced reading evidence for online locality effects in processing logophors: when the logophor’s antecedent was in the local clause, it was processed more quickly than when the antecedent was more distant. Cunnings and Sturt (2012) found that PNP reflexives are read more slowly than coargument reflexives. Although these findings demonstrate that antecedent locality impacts retrieval, care is required in interpreting these results. In particular, reading time evidence alone does not distinguish slowed access to more distant antecedents from rapid access to a poor quality antecedent representation.

**INTERPRETING INTERFERENCE AND LOCALITY: MEMORY MECHANISMS FOR REFLEXIVE PROCESSING**

The empirical evidence surveyed here provides tentative answers to the theoretical questions raised at the outset. With regards to the question of what information is used to guide retrieval, the general lack of interference effects from feature-matched, inaccessible antecedents suggests that antecedent retrieval is effectively guided by syntactic information, such that inaccessible distractors are not generally considered at retrieval (Dillon et al. 2013; Nicol and Swinney 1989; Sturt 2003a,b; Phillips et al. 2011). Although there are a number of studies that have shown interference effects for reflexives, these effects are most reliably observed when there is independent reason to believe that comprehenders should have difficulty constructing a syntactic parse of the input.

It is difficult to relate this observation directly to competing theories of the underlying retrieval mechanism. It is possible that the relatively interference-free retrieval profile for reflexives reflects the use of a syntactically guided search mechanism for antecedent retrieval. However, it is equally plausible that this pattern reflects the use of a cue-based retrieval mechanism for reflexives, with relatively higher weights placed on syntactic cues. Dillon (2011) provides a theoretical argument for the former view. This argument was based on the observation that the syntactic constraints on reflexives are highly relational in nature (i.e. c-command), coupled with the observation that when observers need to search working memory using relational information, they recruit a serial search mechanism (McElree and Dosher 1993). However, it is possible that cue-based retrieval models may capture these findings given an appropriate set of syntactic retrieval cues (see discussion in Kush 2013) and the assumption that syntactic cues are more highly weighted for reflexive dependencies (see discussion of cue weighting in van Dyke and McElree 2011). One important question is whether the cues necessary to distinguish accessible from inaccessible antecedents on such an account are necessarily positional in nature (c.f. Lewis et al. 2006). If the use of positional information is the defining feature of search mechanisms, then the adoption of positional cues in a content-addressable architecture blurs the theoretical distinction between
syntactically organized search and cue-based retrieval mechanisms. In any event, further empirical evidence on the time course of retrieval, as well as the nature of the cues that are used, is necessary before we may draw firm conclusions about the retrieval mechanism used to resolve reflexive dependencies.

One crucial empirical generalization is that the retrieval profile for reflexives is distinct from other linguistic dependencies, such as subject–verb agreement, that reliably show interference effects from inaccessible constituents. This raises the critical question of why reflexives should be relatively immune to interference effects. One possibility is that reflexives are simply representationally distinct from other dependencies such as subject–verb agreement, and this representational distinction leads to a different set of retrieval behaviors for reflexives. A number of researchers have proposed that morphological and discourse constraints are evaluated subsequent to antecedent retrieval (Dillon et al. 2013; Nicol 1988; Nicol and Swinney 1989; Sturt 2003a,b). Dillon and colleagues suggested that this reflects the grammatical organization of reflexive dependencies and noted that a number of theoretical accounts have independently advanced the claim that agreement constraints on reflexives are enforced only once a binding relation has been established (see Baker 2008; Kratzer 2009). One difficulty with this view is that a number of studies report very early effects of morphological feature match and discourse constraints on reflexives. Sturt (2003a), for example, observes that morphological feature match is already evident in first fixation times. The same early time course is observed when the reflexive mismatches the notional number of its antecedent (Kreiner et al. 2012). Likewise, Kaiser et al. (2013) report visual world data that show a very early influence of discourse constraints on logophoric reflexives.

Another critical difference between reflexives and other interference-prone dependencies is the relative position of the critical dependent element in the parse. In English, reflexives generally occur after the verbal head of a sentence, whereas many cases of interference (e.g. subject–verb agreement, NPI interference) are observed at or prior to this point. It is possible that the position of the reflexive relative to the verb is a critical factor in the relatively interference-free profile observed for reflexives. There are a number of reasons why this might matter. One possibility is that this position simply means that inaccessible antecedents are generally less recent and so less available to interfere. Using simulation data, Dillon et al. (2013) argue that this is unlikely to underlie the accurate retrieval profile for reflexives. As King et al. (2012) argued, another possibility is that the post-verbal position allows the processor to maintain an accessible antecedent in focal attention. A final possibility concerns the timing of the construction of a phrase marker. It is possible that interference is observed for subject–verb agreement, NPI dependencies, and subject–verb thematic integration because these dependencies precede a determinate attachment of the subject into the phrase marker. On this view, reflexives are able to accurately use relational syntactic information at retrieval because this information is only reliably available once the verb and subject have been integrated.

**Conclusion**

Overall, the current data suggest that comprehenders use a sophisticated memory access mechanism that displays a relatively interference-free retrieval profile. This relative immunity to interference sets reflexives apart from other well-studied cases of retrieval interference in syntactic comprehension. One important conclusion these data license about the memory architecture of the sentence processor is that retrieval interference is not a hard, unavoidable constraint on the system. Under certain conditions, comprehenders use highly accurate retrieval routines that appear to use relational information to limit memory search to
syntactically licensed positions. However, many important theoretical questions remain unresolved. Before firm conclusions about the specific retrieval mechanism can be drawn, further research on the time course of antecedent retrieval is required. It also remains unclear why reflexives should show the distinct retrieval profile that they do, and so, much further research is necessary to tease apart the representational and processing factors that may underlie this difference.

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Short Biography

Brian Dillon is an assistant professor in the Department of Linguistics at the University of Massachusetts, Amherst. His specialization is in psycholinguistics, with a focus on the working memory systems that support syntactic comprehension. His work on sentence comprehension uses a variety of experimental and computational methods and has investigated a variety of languages including Hindi, Inuktitut, and Mandarin Chinese. He has published articles on the comprehension of subject–verb agreement and reflexive dependencies, the grammatical status of island constraints, predictive processes in sentence comprehension, negative polarity licensing in comprehension, discourse structure and syntactic complexity, category formation in phonological learning, and computational models of working memory in sentence processing. In 2011, he received his PhD in linguistics from the University of Maryland, College Park. He also holds a BA in linguistics from the State University of New York at Buffalo.

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Works Cited


