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A Dual-Process Activation Model: Processing definiteness and information status

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The introduction of a new discourse referent with a descriptive noun phrase involves the introduction of a new concept and the assignment of a referent to that concept. Concepts can be inferred from previous context, and thus be pre-activated (e.g., *gym* activates the concept of the noun *trainer*), or can be discourse-new. The function of the definite article is to signal unique identifiability of the referent, and the function of the indefinite article is to assert the existence of a set introduced by the descriptive content. We tested to what extent concept pre-activation and the function of the definite and indefinite article affect referent activation during retrieval and integration as well as referent activation at the sentence level. In Experiment 1, a visual world eye tracking experiment, we found that inferred referents of definite noun phrases were more accessible at subsequent pronoun resolution than inferred referents of indefinite noun phrases. No effects of definiteness were observed for referents with brand-new concepts. In Experiment 2, recording event-related potentials at the noun phrase itself, referents with pre-activated concepts were accessed and integrated more easily than referents with brand-new concepts. Furthermore, definite and indefinite articles yielded differently large frontal negativities. We discuss our results within a Dual-Process Activation Model, which distinguishes two processes in referent management: concept activation and referent activation. Our data suggest that these processes not only affect noun phrase processing but also trigger specific pragmatic inferences at the sentence level.

1 Introduction

To successfully establish a discourse model that is similarly understood or used by a speaker and a hearer, the speaker needs to indicate which referents are at the focus of attention and which referents are not. This indication, which is linked to the concept of referent management, includes the introduction of new referents as well as the maintenance of referents that have already been added to the discourse. Discourse referents can be introduced and later be mentioned again by different referential expressions, such as pronouns, proper names, and definite or indefinite noun phrases. In this paper, we focus on referents of definite and indefinite noun phrases and the information status associated with these noun phrases. That is, referents of definite and indefinite noun phrases can be associated with a concept that can be inferred from previous context or with a concept that is new. As will become clear from our discussion in the next section, crossing definiteness marking and information status can lead to interesting assumptions about noun phrase processing as well as specific inferences that are triggered by the linguistic context

and typically occur at the sentence level. The goal of the present study is to test these assumptions empirically in moment-by-moment comprehension.

1.1 Prominence, definiteness marking, and information status

An influential approach to referent management has been Centering Theory (Brennan et al. 1987; Gordon et al. 1993; Brennan 1995; Grosz et al. 1995; Strube & Hahn 1999). This theory assumes that (a) new discourse referents are added to a list of already existing referents and that (b) all referents are ranked according to their activation level or prominence (see also von Heusinger 2000). It is important to note that this ranking of referents is not at all rigid or fixed. It rather changes and is updated continuously as discourse unfolds. Now, while Centering Theory states that the prominence of the referents in an utterance is by and large determined by the referents' grammatical role, more recent research has shown that grammatical role is only one factor among many, including thematic role (Stevenson et al. 1994; Ferretti et al. 2009; Fukumura & van Gompel 2010; Schumacher et al. 2015), topic-hood (Kaiser 2011), focus (Crawley 2001; Kaiser 2011), aspect (Kehler et al. 2008; Kehler & Rohde 2013), implicit causality (Stevenson et al. 1994; Arnold 2001; Fukumura & van Gompel 2010; Hartshorne & Snedeker 2013), and discourse goals (Jasinskaja et al. 2015).

But how can we measure a referent's prominence or activation status? There have been several approaches in the literature. Centering Theory focuses on the local coherence between two adjacent sentences and uses the ranking of the discourse referents to determine which anaphoric expression will be used for re-mentioning. The claim is that speakers use a pronoun to refer to the most prominent, i.e. the highest ranked, referent, and a definite noun phrase to refer to less prominent, i.e. lower ranked, referents. This approach reflects the more general idea that the prominence level of a discourse referent can be assessed by testing which type of referring expression a speaker uses to refer back to that referent (cf. Ariel 1988; Gundel et al. 1993). The more prominent a referent is, the more likely it is that a speaker will use a reduced expression, such as a pronoun, to refer back to it.

Another approach is to test ambiguous pronoun resolution, such as the resolution of a personal pronoun (Crawley & Stevenson 1990; Stevenson et al. 1994; Bosch et al. 2007; Bouma & Hopp 2007; Kaiser & Trueswell 2008; Kaiser 2011; Kurczek et al. 2013; Rohde & Kehler 2014). In this approach, the prominence level or accessibility of a referent is measured by the degree to which a subsequent ambiguous pronoun is resolved to that referent. For example, it has been shown that comprehenders more often resolve an ambiguous personal pronoun to the preceding subject than the preceding object referent (Arnold 2001).

In the present study, we assess the prominence level and accessibility of discourse referents of descriptive noun phrases. We measure a referent's accessibility at the point the referent is newly introduced in discourse, using event-related brain potential (ERPs, Experiment 2), and at the point a following ambiguous pronoun needs to be resolved (Experiment 1). The central claim is that the introduction of a new discourse referent through a descriptive noun phrase and the accessibility of that referent at later re-mentioning involve two separate processes. One process relates to the noun phrase's descriptive content, the other to the referential choice a speaker or hearer needs to make. While these two processes have been attested for noun phrase processing in previous studies, we extend these studies by also testing for contextually induced pragmatic inferences emerging at the sentence level, i.e. after the noun phrase has been retrieved and integrated. Indeed, such inferences are predicted to occur following considerations from more theoretical accounts. Our aim, then, is to provide a comprehensive model of descriptive

noun phrase processing that builds on empirical data and goes beyond noun phrase retrieval and integration.

The descriptive content of a noun phrase provides the comprehender with a concept, which contributes most of the noun phrase's semantics. What is important for the present study is the observation that the concept of a noun phrase can establish a relation to an already activated concept, the concept of the *anchor*. According to Prince (1981; 1992, more recently Baumann & Riester 2013), the concept or information status of a newly introduced noun phrase can be *given, inferred* (*inferable*) or *brand-new*, although in the present study, we will only test referents with inferred and brand-new information statuses.

For example, in (1a), the concept of the noun phrase *the pretty boy next to the window* is brand-new, as the concept PRETTY BOY cannot be inferred from the concept of any noun phrase in the preceding context. In contrast, the concept of *the trainer next to the window* in (1b) is already available at noun phrase encounter, as the concept TRAINER can be inferred from the concept GYM. Or, put differently, the concept of the noun *gym* pre-activates the concept of the noun *trainer*.

(1)   The gym was very crowded, as always.
  a.   Philip stared at the pretty boy next to the window.
  b.   Philip stared at the trainer next to the window.

While the descriptive content of a noun phrase can activate a concept that delimits or determines the set of potential referents, the definite and indefinite article lead the comprehender to select a matching referent from that set. Since Frege (1892) and Russell (1905), the semantics of the definite and indefinite article is one of the main research topics in formal semantics and analytic philosophy. While most researchers agree that the semantics of the indefinite article comes with an existential entailment, such that it signals to the comprehender that a referent exists without introducing an individual referent, the semantics of the definite article is subject to some debate (see Elbourne 2013 for an overview). Russell (1905) and Neale (1990) propose that the definite article is a quantifier that expresses an existence and uniqueness entailment of an entity that satisfies the descriptive material. Frege (1892), Strawson (1950), Heim (1991), and Elbourne (2013) assume that definite noun phrases are referential expressions with a uniqueness presupposition, such that definite noun phrases always introduce an individual referent. Finally, Heim (1982), Kamp (1981), and Roberts (2003) suggest that the definite article expresses a familiarity presupposition, such that definite noun phrases can only felicitously be used when they can be linked to an antecedent. In line with Heim (1991), Strawson (1950), and Elbourne (2013), we assume that the definite article contributes a uniqueness presupposition and that the indefinite article triggers an existential entailment.

Based on the examples presented in (2)–(5) below, we further propose that a noun phrase's information status (inferred or brand-new) and definiteness marking (definite or indefinite) interact in interesting ways and that they do so at the level of a sentence's proposition. For brand-new definite noun phrases like *the pretty boy next to the window* in (2) the contribution of the definite article is to license a unique set, which is described by the noun phrase. For example, in (2) we assume that there is exactly one pretty boy in the described event.

(2)   The gym was very crowded, as always. Philip stared at the pretty boy next to the window.

For inferred definite noun phrases like *the trainer next to the window* in (3), on the other hand, the definite article licenses the uniqueness of the associated concept. Unlike for

brand-new definites, the concept of inferred noun phrases, TRAINER in (3), is pre-activated by an anchor, *gym*, and therefore the referent must be related to the anchor concept, GYM. We might then say that the main difference between referent uniqueness in (2, *the pretty boy*) and referent uniqueness in (3, *the trainer*) is that only in (3) does a comprehender identify a unique referent within a pre-activated set of referents.

(3)   The gym was very crowded, as always. Philip stared at the trainer next to the window.

More interesting, and perhaps more controversial, is the way indefinites can introduce discourse referents. As stated above, we agree that the indefinite article triggers an existential entailment. That is, indefinite articles express that the set of potential referents is non-empty. The particular type of referent that is assigned to the concept, then, depends on the linguistic context and additional pragmatic inferences, which, we argue, are linked to the information status of the noun phrase. For brand-new indefinites and in the absence of any contextual information (e.g., a domain restriction or common frame/event knowledge), sentences like the one in (4a) have the same truth conditions as sentences like the one in (4b). Nevertheless, in a situation where we know that more than one trainer lives in the building, uttering (4a) is pragmatically infelicitous (Heim 1991).

(4)   a.   A trainer is living in the building.
            b.   One or two trainers are living in the building.
            c.   The trainer is living in the building.

The indefinite noun phrase *a trainer* in (4a) leads to a uniqueness implicature that follows from the Maxim of Quantity: (4b, *one or two trainers*) and not (4a, *a trainer*) should be uttered if there is reason to believe that more than one trainer lives in the building. Thus, the uniqueness implicature of (4a) makes *a trainer* very similar to *the trainer* in (4c), where uniqueness is presupposed (see Heim 1991 for a discussion).

Turning to the inferred indefinites, we first note that, given specific context information, a speaker often knows whether there must be a unique referent that fits the concept or not. For example, in the context of a gym class, a comprehender presumably knows that there is exactly one trainer. In the context of a gym, on the other hand, the comprehender might assume that there are multiple trainers although it is also plausible that there is only one trainer. To make this point more explicit, consider *the trainer* in (5a) and *a trainer* in (5b).

(5)   The gym was very crowded, as always.
            a.   Philip stared at the trainer next to the window.
            b.   Philip stared at a trainer next to the window.

The anchor *gym* in the first sentence activates a number of concepts, including TRAINER, PARTICIPANT, WORK OUT, SWEAT, etc. By virtue of belonging to the pre-activated set of referents, the concept associated with the descriptive noun phrase, i.e. TRAINER, is already activated at the point the noun phrase (*the trainer* in (5a) and *a trainer* in (5b)) is encountered. Just like for the inferred definites, the pre-activated concept delimits the set of potential referents.

However, unlike for the definites cases, the indefinite article expresses that there is at least one trainer in the described event, which is coherent with the pre-activation of the concept TRAINER. Under these conditions, i.e. when additional information or a domain restriction is available, the indefinite article additionally expresses a non-uniqueness

condition, namely that there is more than one trainer. In such cases, the indefinite article does not contrast with *one and more,* but instead with the definite article, which expresses uniqueness. In line with the principle of Maximize Presupposition discussed in Heim (1991; 2011) if a speaker knows for a particular setting that there is only one trainer, she or he is urged to use the definite article. Thus, if she/he uses the indefinite article, she/he is likely to signal that there is more than one trainer. As an illustration, consider the statement *Bill has a bicycle. He's cleaning a saddle.* This statement seems infelicitous, as it contrasts with our knowledge that a bicycle has exactly one saddle.

It then seems that the indefinite article can interact with the immediate linguistic context in very different ways: When there is no domain restriction and no pre-activation by the previous context, a uniqueness implicature emerges. When there is a domain restriction or pre-activation through previous linguistic context, a non-uniqueness condition is triggered (see Heim 1991 for an extensive discussion of this apparently paradoxical behavior).

Following from the considerations above, we propose that the prominence and activation status of definite and indefinite noun phrases with brand-new concepts is likely to be very similar. For both noun phrases, a brand-new concept is introduced and the associated referent is identified either via a uniqueness presupposition (for definite articles) or a uniqueness implicature (for indefinite articles). For definite and indefinite noun phrases with inferred concepts, we suggest that the former are more prominent and should come with a higher activation status than the latter. This is because comprehenders can select or activate a uniquely identifiable referent for inferred definites but not for inferred indefinites. Indeed, it is possible that comprehenders remain with the concept, e.g., the concept of *trainer* in (5b, *a trainer* in the context of a gym) without even activating a referent.

1.2 Experimental approaches to information status and definiteness marking

The idea that the introduction of a referent with a descriptive noun phrase involves two processes is based on the semantic analysis that descriptive noun phrases consist of a discourse referent and some descriptive content. Karttunen (1969), Kamp (1981), Heim (1982; 2011), and Farkas (2002) have long pointed out that a descriptive noun phrase has two essential parts: a referent that licenses anaphoric links in the subsequent discourse, and a descriptive part that is associated with the concept that undergoes interpretative variation, depending on the particular context of interpretation. What is missing, however, is a systematic empirical investigation of these two parts in moment-by-moment comprehension. We are also not aware of a comprehensive model that implements the two processes and aims at accounting for noun phrase processing, including referent access and integration, as well as for additional inferences that may be obtained at the sentence level.

The lack of more empirically driven data is partly due to the fact that most studies in the field used proper names for the introduction of new discourse referents – presumably because proper names carry little conceptual information that could potentially interfere with the parameters under investigation (e.g., grammatical role, thematic role, implicit causality, etc.).

Two exceptions, both of which used event-related brain potentials (ERPs), are Burkhardt (2006) and Schumacher (2009). For ERPs at the noun, both studies found that inferred referents were accessed more easily than brand-new referents (see also Schumacher & Hung 2012), which is fully compatible with the notion of concept pre-activation in the case of inferred referents. Schumacher (2009) also found that definite articles yielded stronger processing costs than indefinite articles, suggesting that the uniqueness condition of definite articles was computed at article encounter. Interestingly, for ERPs elicited at the

noun neither Burkhardt (2006) nor Schumacher (2009) found any effect of definiteness marking. In other words, nouns of definite marked noun phrases behaved very similarly to nouns of indefinite marked noun phrases. This might suggest that, while unique vs. non-unique identifiability of a referent is triggered at the article, it is only fully computed at the sentence level and does therefore not significantly affect the retrieval or integration of the referent at the point that referent is encountered, i.e. at the denoting noun. Thus, if brand-new indefinites trigger a uniqueness implicature and inferred indefinites a non-uniqueness implicature, these additional pragmatic inferences do not seem to be found at the noun phrase but rather at the sentence level.

Additional support for separate effects of information status and definiteness marking and some preliminary support for the claim about pragmatic inferences at the sentence level come from Brocher et al. (2016). The authors created short stories consisting of a context sentence that provided an anchor (e.g., *gym*), a second sentence that introduced two human referents, one in subject and one in direct object position, and a third sentence that included an ambiguous personal pronoun. The manipulation of interest pertained to the referent in object position of the second sentence, which was always a descriptive noun phrase.

Monitoring eye fixations time-locked to the onset of the pronoun, Brocher et al. found that participants looked more at the picture of inferred definite than the picture of inferred indefinite referents. No differences in fixation times were observed for brand-new definite and brand-new indefinite referents. These data are compatible with the view that for both brand-new definite and indefinite descriptions, comprehenders identified and activated a unique referent, either through presupposition or through implicature. Brocher et al.'s (2016) data are also compatible with the view that comprehenders did not select and activate a unique referent for inferred indefinites, presumably because these expressions triggered a non-uniqueness implicature.

In interpreting their results, Brocher and colleagues proposed a Dual-Process Activation Model, which is summarized in Figure 1. The model states that the introduction of a new discourse referent with a descriptive noun phrase involves two processes, concept activation
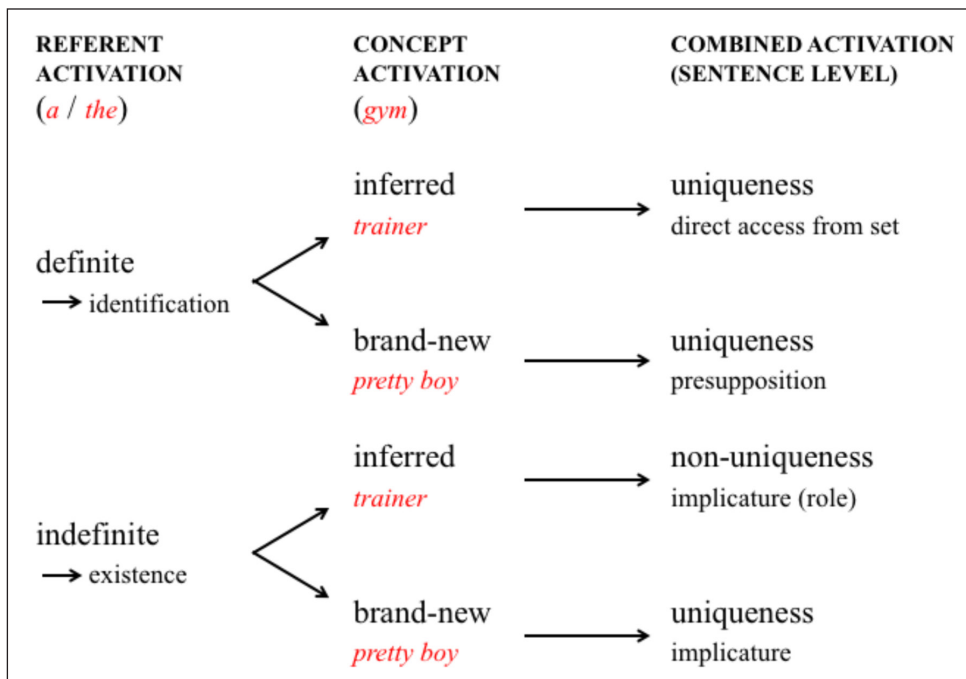
Figure 1: Illustration of the Dual-Process Activation Model.

and referent activation. Concept activation is linked to a noun phrase's information status: Concepts of inferred noun phrases are pre-activated by an anchor expression in preceding context, while concepts of brand-new noun phrases are not pre-activated. This explains why discourse referents of inferred noun phrases were accessed more easily than referents of brand-new noun phrases in Burkhardt (2006) and Schumacher (2009). Referent activation is linked to the definite and indefinite article of the noun phrase. Definite articles lead the comprehender to uniquely identify a referent, whereas indefinite articles lead the comprehender to assert referent existence. This distinction is in line with the data reported in Schumacher (2009), who found differences in the ERP signature between definite and indefinite articles.

Thus, the findings from previous studies on descriptive noun phrase processing (retrieval and integration) are compatible with the assumption that there are two distinct processes in referent management, namely concept activation and referent activation. The more novel part of the Dual-Process Activation Model, then, is that it predicts the integration of specific pragmatic inferences at the sentence level. The claim is that when referent activation triggers an existential entailment and the concept of the associated noun phrase is brand-new, comprehenders can identify a referent through a uniqueness implicature. If, in contrast, referent activation triggers an existential entailment and the concept of the associated noun phrase is already activated, comprehenders draw a non-uniqueness implicature, which does not lead to the activation of an individual referent. This part of the model explains why brand-new indefinites patterned with their definite counterparts in Brocher et al. (2016). Under both conditions, the referent was uniquely identified. It also explains why inferred definites were more accessible than inferred indefinites. Inferred definites not only led to unique identifiability of a referent, but also allowed comprehenders to directly access that referent from the pre-activated set. Inferred indefinites, finally, led to a non-uniqueness implicature so that there was no dedicated referent that the noun phrase could refer to, promoting the competing subject referent to an even stronger candidate for pronoun resolution.

Indeed, Brocher and colleagues speculated that inferred indefinites might not introduce an individual discourse referent, but rather a role, i.e. a complex functional structure that itself can be filled with individual referents (cf. Zwarts 2014), similar to weak referential items that are introduced by bare nouns and weak definites (Carlson et al. 2013). In other words, when a noun phrase is encountered that can be linked to a previously activated concept and its designated set, the definite article uniquely identifies one element, i.e. the unique element of the set, while the indefinite article might merely assert that the set is non-empty. This can lead to some processing costs when an individual needs to be identified, which was the case at pronoun encounter in Brocher et al. (2016).

Although the Dual-Process Activation Model is the first model of descriptive noun phrase processing that goes beyond the noun phrase level and extends to discourse-level processing, and although the results of Brocher et al. (2016) largely converge with previous findings (Burkhardt 2006; Schumacher 2009), there are two shortcomings to their materials. First, Brocher and colleagues used potentially different sources of uniqueness for inferred and brand-new referents and, as a consequence, also used different nouns in the inferred conditions and the same noun in the brand-new conditions. In the inferred definite condition, the authors used referents whose concept was unique by virtue of anchor encounter, such as *the trainer* in the context of a gym class. In the inferred indefinite condition, they used referents whose concept was non-unique by virtue of anchor encounter, such as *a participant* in the context of a gym class. For brand-new referents, in contrast, referent uniqueness was signaled to the comprehender solely by the article of the critical noun phrase (*a pretty boy* vs. *the pretty boy* in the context of a gym class). We might then argue

that Brocher et al. (2016) investigated different sources of uniqueness in their inferred and brand-new conditions. In the former, they tested uniqueness triggered by the anchor and the world knowledge associated with it (knowing what a gym class looks like means knowing that there will be exactly one trainer). In the latter, they tested uniqueness triggered by the article of the noun phrase. Because Brocher et al.'s most critical finding pertains to the fact that (non-)unique identifiability differently affected the accessibility of inferred and brand-new referents, it is important to rule out the possibility that their findings were due to the kind of unique identifiability tested in the materials.

Second, Brocher et al.'s study was about pronoun resolution, measuring the competition between the object and the subject referent. In their study, listeners encountered the ambiguous pronoun after critical referents had already been introduced and therefore after processing of the critical descriptive noun phrase. Although this design allowed the authors to test for the integration of specific pragmatic inferences, it did not allow them to test concept activation and referent activation at the very point the noun phrase was retrieved and integrated in discourse.

1.3 Overview of experiments

In the two experiments we report here, we addressed both shortcomings in Brocher et al.'s (2016) study discussed above and further tested the validity of the Dual-Process Activation Model. We created short stories consisting of three sentences. The first sentence included a noun phrase that served as anchor providing the concept of the inferred referents. No such anchor was provided for brand-new referents. The second sentence introduced two (human) referents. While the subject referent was always a proper name, the concept of the critical object referent could either be inferred from preceding context (inferred) or not (brand-new). Furthermore, the object noun phrase was a noun phrase with either a definite or an indefinite article. Crucially, except for the object noun phrase, all materials were identical across conditions.

In Experiment 1, we tested whether, at the sentence level, comprehenders integrate the various pragmatic inferences discussed above and reflected in the Dual-Process Activation Model (cf. Figure 1) when source of uniqueness is held constant between inferred and brand-new referents. We used a visual world eye tracking experiment that closely followed the design and procedure of the eye tracking study presented in Brocher et al. (2016): We measured eye fixations while participants resolved the ambiguous pronoun in the final sentence of the stories. If Brocher et al.'s results in their inferred conditions extend from anchor-triggered uniqueness (*gym class – the trainer*) to article-triggered uniqueness (*gym – the trainer*), we should find more looks to the object picture in the inferred definite than the inferred indefinite condition. This would be in line with the assumption that comprehenders activate a unique referent when they encounter a definite noun phrase with an inferred concept, while they do not activate an individual referent when they encounter an indefinite noun phrase with an inferred concept. No large differences should be obtained between the brand-new definite (*gym – the pretty boy*) and the brand-new indefinite condition (*gym – a pretty boy*). Both these conditions should lead to unique identifiability of the associated referent.

Experiment 2 used ERPs and tested specific neurophysiological markers of referent access and integration at the very point the noun phrase and associated referent were mentioned for the first time in the discourse. This experiment, therefore, addressed the second shortcoming in Brocher et al.'s study discussed above. Because Experiment 2 tested noun phrase processing directly (while Experiment 1 tested referent accessibility at re-mention), this study, unlike the eye tracking study, used the same noun in the inferred

and brand-new conditions. It therefore tested the same concepts across these conditions. Experiment 2 is important because the two processes incorporated in the Dual-Process Activation Model, i.e. concept and referent activation, are expected to also affect the retrieval and integration of definite and indefinite noun phrase. Referent activation is tightly linked to the processing of the article, while concept activation is linked to the processing of the noun. As will become clearer below, we expected nouns with inferred concepts to be accessed and integrated more easily than nouns with brand-new concepts.

2 Experiment 1: Ambiguous pronoun resolution

In Experiment 1, we used a visual world eye tracking paradigm and presented participants with short stories that consisted of three sentences (see Table 1). The first sentence introduced an anchor (Prince 1981; 1992) that activated various concepts (e.g., *gym* activates TRAINER). The second sentence introduced two human referents. The third sentence included a personal pronoun that could be resolved to the preceding subject or object referent. We used ambiguous pronoun resolution as a marker of the relative activation status and accessibility of a referent: The more accessible a referent is by virtue of its information status and/or definiteness marking, the more participants should look at the picture depicting that referent at pronoun encounter. Crucially, pronouns require the identification of a specific referent (Chastain 1975; Kamp 1981; Heim 1982; see also Neale 1990: 175–179 for a discussion). That is, at pronoun encounter a listener needs to identify an individual and cannot remain with a concept of an expression (such as a role associated with it).

We manipulated the information status and definiteness marking of the noun phrase in object position as a proxy for concept activation and referent activation, respectively. All other materials were identical across conditions. More specifically, the concept of the referent in object position could be inferred or was brand-new (*trainer* or *pretty boy*) and the noun phrase was definite or indefinite marked (*the trainer/pretty boy* or *a trainer/pretty boy*).[1] In line with previous studies on referent accessibility, we predicted overall more looks to the picture of the subject referent than the picture of the object referent, because (a) subject referents are generally more accessible than object referents (Crawley & Stevenson 1990; Stevenson et al. 1994; Arnold et al. 2000) and (b) subjects are more likely to be mentioned again with a pronoun than objects (see e.g., Fukumura & van Gompel 2010). In a way, then, our measure of object referent accessibility was a measure of dispreference. We asked whether looks to the object picture vary as a function of

Table 1: Sample experimental materials for Experiment 1.

(1) The gym was very crowded, as always.	
(2) Philip stared at _____	(a) a trainer next to the window.
	(b) the trainer next to the window.
	(c) a pretty boy next to the window.
	(d) the pretty boy next to the window.
(3) When the lights went out, *he* used his cell phone as a flashlight.	

Note: Materials are translated from German. Sentences (1) and (3) were identical in all conditions; the noun phrase in direct object position in sentence (2) was manipulated to yield inferred/indefinite (2a), inferred/definite (2b), brand-new/indefinite (2c), and brand-new/definite descriptions (2d).

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[1] Note that *pretty boy* is the English translation of the German example *Schönling*. All noun phrases in direct object position consisted of exactly one noun in the original materials (see Appendix A of the Online Supplement for a full list of materials).

information status and definiteness marking when the associated referent competes with the more prominent subject referent.

The Dual-Process Activation Model laid out above predicts that at the sentence level (cf. Figure 1) and for referents with pre-activated concepts (inferred noun phrases), the definite article leads to identification of an individual referent, while the indefinite article leaves the comprehender with the assertion of referent existence, such that no individual referent is identified or activated, but rather a role. For referents with brand-new concepts, the model predicts that, at the sentence level, comprehenders identify a unique referent for both definite marked noun phrases (through presupposition) and indefinite marked noun phrases (through implicature).

Thus, the model predicts an interaction between information status and definiteness marking at pronoun resolution. We should find fewer looks to the object picture in the inferred indefinite than in the inferred definite condition ((2a) vs. (2b) in Table 1) and, at best, minimal differences between the brand-new indefinite and brand-new definite condition ((2c) vs. (2d)). This is predicted because for inferred indefinite referents, unlike for inferred definite referents and brand-new referents, listeners have not identified a specific referent, which increases the likelihood that they will resolve the ambiguous pronoun to the competing subject referent. This finding would replicate Brocher et al. (2016) and would suggest that their data from the inferred conditions extend from anchor-triggered (*gym class – the trainer*) to article-triggered uniqueness (*gym – the trainer*).

If, on the other hand, Brocher et al.'s results were due to the testing of different sources of uniqueness and if comprehenders do in fact not integrate the specific pragmatic inferences discussed in the introduction, we might expect more looks to the pictures of inferred rather than the pictures of brand-new referents. This would be compatible with the easier retrieval of the former, compared to the latter, reported in Burkhardt (2006) and Schumacher (2009).

Experiment 1 also allows us to test predictions of two other (classes of) more theoretically grounded theories. The Givenness Hierarchy (Ariel 1988; Gundel et al. 1993) belongs to the family of accessibility scales. These scales provide a linear ordering of accessibility along the specific linguistic realization of the noun phrase: Lexically more reduced forms are used for more accessible referents, while lexically full forms are used for less accessible referents. Notably, to our knowledge, none of the proposed accessibility scales considers information status to be a relevant factor in accessibility. That is because accessibility scales typically represent potentials for anaphoric expressions, i.e. they are backward-looking, and not the potential of first mentioned referential expressions to scale the prominence of the associated referent. That is, they are not forward-looking. The crucial point for Experiment 1 is that accessibility scales predict definite descriptions to lead to higher referent accessibility and thus more looks to the associated picture when the object noun phrase is definite than when it is indefinite-marked, independently of information status.

Functional Centering Theory (Strube & Hahn 1999) adds information status to the list of parameters that potentially affect referent management. This theory describes the forward-looking potential of referential expressions in addition to their backward-looking potential. While the more classical Centering Theory takes grammatical role (subject > object) as the main factor affecting the prominence of a referent, Functional Centering Theory assumes that given or evoked referents are more accessible than inferred referents, which, in turn, are more accessible than brand-new referents. This theory then predicts overall more looks to the picture of the object referent when the concept can be inferred than when it is brand-new.

2.1 Method

2.1.1 Participants

Twenty-nine students of the University of Cologne participated in the experiment for course credit or monetary compensation (EUR 8 per hour). All participants were monolingual speakers of German and self-reported normal or corrected-to-normal vision. For all data presented in this paper, no participant took part in more than one study. The experiment was approved by the ethics committee of the German Research Foundation (DFG).

2.1.2 Materials

All materials were in German. We constructed 32 short stories like the one in Table 1 (all materials are provided in their original German version in the Online Supplement, Appendix A). All stimuli consisted of three sentences. The context sentence (sentence (1) in Table 1) included an anchor (*gym*) with which the concept of the inferred noun phrase (TRAINER) was much more strongly associated than the concept of the brand-new noun phrase (PRETTY BOY, see typicality norming below). The second sentence introduced two human referents, one in subject and one in direct object position. The referent in subject position was realized by a proper name and was the same across conditions. We used proper names as subjects because, first, they do not interfere with concept activation, as they do not introduce concepts (Kripke 1977; Sanford et al. 1988; Gordon et al. 1993; 2004; Abbott 2002), and, second, because they are acceptable for the introduction of brand-new referents in subject position.

The referent in direct object position was realized by a descriptive noun phrase and was either inferred and indefinite (*a trainer*), inferred and definite (*the trainer*), brand-new and indefinite (*a pretty boy*), or brand-new and definite (*the pretty boy*). It should be noted that, unlike Burkhardt (2006), Schumacher (2009), and Brocher et al. (2016), we used referents in direct object position that were possibly but not necessarily unique judging from information provided by the anchor. For example, it is plausible that there is only one trainer at a gym. However, it is equally plausible that there are two or more trainers at a gym. In the third sentence, participants encountered an ambiguous personal pronoun, which could be interpreted as the subject or object referent of the preceding sentence. The third sentence, just like the context and the second sentence, did not include any disambiguating information. This means that the stories never revealed which referent in the story the pronoun referred to.

All noun phrases in direct object position included a prepositional phrase (*next to the window* in Table 1) to license the use of the definite article in the definite conditions, especially in the case of brand-new referents. That is, the prepositional phrase served to preserve naturalness of our experimental materials by restricting the context in a way to make definite article use felicitous. As we will discuss in more depth in the General Discussion, it is likely that comprehenders used the prepositional phrase to further restrict the set of potential referents associated with the noun phrase.

It is important to reiterate that all materials except for the object noun phrase of the second sentence were exactly the same across the four conditions. This is important because previous literature has shown that grammatical role, thematic role, verb bias, and other factors (see introduction) can affect referent management, including next mention bias and choice of referring expression. Therefore, if we find differences in pronoun resolution between the tested conditions, either because there are differences in accessibility or because there are differences in the likelihood of being mentioned again with a pronoun, these differences can only be due to differences in information status and/or definiteness marking, the two factors under investigation.

Typicality Norming. To obtain a quantifiable measure of strength of inference between anchor and critical items, we asked 34 students of the University of Cologne to rate the typicality of our referents in their respective contexts. Participants judged, for example, how typical they thought a trainer was in the context of a gym. To that end, we presented participants with the context sentences of the main experiment (*The gym was very crowded, as always*), followed by a noun, which never included an article (*trainer*). Participants judged for each noun individually how typical they thought the noun was in the provided context, using a scale from 1 = "not typical at all" to 7 = "very typical." A total of 64 experimental items were distributed across two presentation lists, such that participants saw each context sentence and target noun only once, and conditions were counterbalanced across lists. Each list also included 12 filler items with moderately typical nouns (e.g., *police officer* in the context of an open-air concert).

As expected, nouns of the inferred conditions were judged to be significantly more typical in their contexts than nouns of the brand-new conditions. The former received a mean typicality score of 5.91 (*SE* = 0.16, range = 3.9–6.9), the latter a mean typicality score of 2.75 (*SE* = 0.18, range = 1.2–4.8). A planned paired *t*-test (two-tailed) showed that nouns of the inferred conditions were significantly more typical in their contexts than nouns of the brand-new conditions, $t(33) = 12, p < .001$.

All short stories of the main experiment were recorded by a trained female speaker. Stories of each item and condition were recorded separately (which led to the recording of $32 \times 4 = 128$ experimental stories). After recording, the final sentence was separated from the other two preceding sentences for each recording and then replaced by a particular final sentence of the respective item using Praat (Boersma 2001). In other words, final sentences, which contained the ambiguous pronoun, were identical across the four conditions of every item.

Materials were distributed across four lists and each list contained 32 experimental and 64 filler stories. Each list, then, contained eight items of each condition with no repetition of items within lists. An attempt was made to keep fillers as similar as possible to the experimental stories, both in structure and length. For example, because all experimental items introduced two male human referents to promote ambiguity between two preceding noun phrases, filler stories also only mentioned male human referents. Furthermore, to direct participants' attention away from the manipulations within the materials, fillers included lexical ambiguity (e.g., *bank, calf*, etc.) as well as attachment ambiguities (e.g., *The police officer saw the criminal with the binoculars*). Fillers never contained an ambiguous pronoun anywhere in the text.

Three kinds of pictures were created. One set of pictures corresponded to the subject referent of the second sentence, one to the object referent, and one to the look-away object, which was always mentioned shortly before the ambiguous pronoun in the final sentence (e.g., *lights*, see Table 1). An example display is provided in Figure 2. The picture of the look-away object was always presented at the top middle of the screen. The pictures of subject and object referents appeared at the left and right side of the screen, with complete counterbalancing of subject and object picture position across the four conditions and lists.

Note that, while pictures of the critical object referents could be linked to their referents in the texts through specific visual features (e.g., a trainer wearing a track suit), this was not possible for subject referents – being proper names, which are not associated with particular features. We therefore divided the experiment into 16 blocks with six stories per block. At the beginning of each block, participants saw the pictures and names of the subject referents on a separate screen. This allowed participants to become familiar with
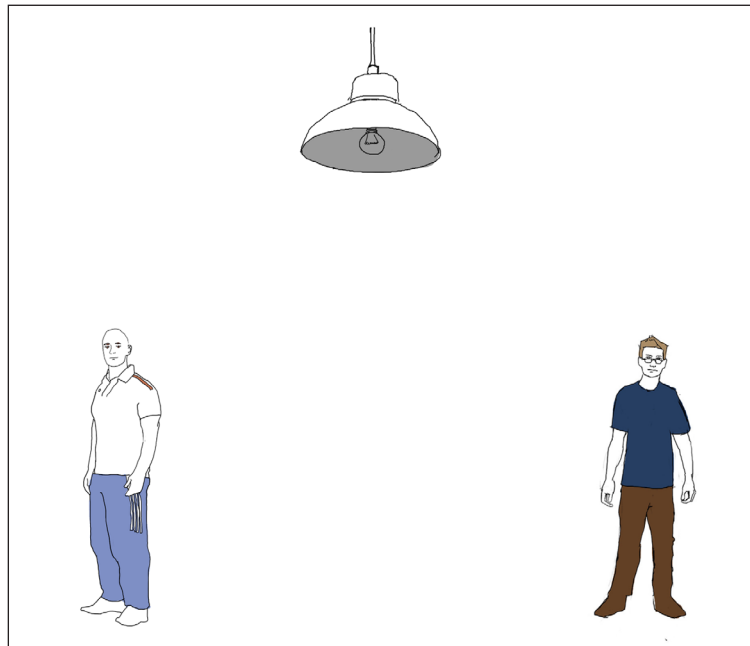
Figure 2: Example visual display for Experiment 1. The referent in subject position (*Philip*) is presented at the right, the referent in object position (*the trainer*) is presented at the left, and the look-away object (*lights*) is presented at the top.

the pictures of the subject referents appearing in the present block. Participants were told that they should simply familiarize themselves with the six individuals for later recognition, but that they would not be asked questions about any physical properties of these individuals (e.g., regarding their clothes).

Each block comprised two experimental and four filler stories. The order of blocks and the order of trials within blocks were randomized for each participant individually. Finally, each trial was followed by a "yes"/"no" comprehension question (half "yes," half "no" responses). For experimental items and most of the filler items, comprehension questions targeted some information from the context sentence.

2.1.3 Procedure

Eye movements and fixations were recorded using an EyeLink 1000 eye tracker configured with a tower mount. Participants listened to the short stories over headphones while looking at a computer screen. Each block of trials started with familiarization of the subject referents of the current block. Participants were given as much time as they needed to become familiar with the pictures and associated names (e.g., *Philip*). They then pressed a button to initialize the first trial of the block, which, in turn, initialized presentation of the visual display. With a delay of 500 ms, auditory presentation of the story started while the pictures remained on the screen. Participants were asked to carefully follow the stories for comprehension and were told that there was no correct or incorrect picture to look at but that pictures might help them follow the stories. Four practice trials were provided prior to the first experimental block.

2.2 Results

For the discussion of fixation times at pronoun encounter, we will continue to speak of inferred and brand-new referents although, of course, at pronoun encounter referents are no longer inferred or brand-new. Changing the terminology between first (full noun phrase) and second encounter (pronoun), though, would be rather confusing and all

critical manipulations (information status and definiteness marking) pertain to the first encounter of the referents.

Mean accuracy to comprehension questions was 84% and all participants performed above 80%. Before statistical analyses, we excluded 7.4% of the data due to blinks and an additional 1.7% of data points because no picture on the screen was fixated within a specific time frame (see below). For the remaining data, we analyzed all fixations between pronoun onset and 1400 ms post pronoun onset. We then divided the resulting 1400 ms into a baseline time frame, consisting of the first 200 ms post pronoun onset, and an additional four time frames, each consisting of 300 ms. Note that the first frame of interest ranged from 200 ms to 500 ms post pronoun onset, because it takes around 200 ms for the eye to launch a saccade as response to a stimulus (Matin et al. 1993). We calculated mean fixation times to the picture of the subject referent, object referent, and look-away object per participant, trial, and time frame. Whenever a fixation within a frame landed on one of the three pictures, the associated referent received a score of 1, while the two non-fixated referents received a score of 0.

Statistical analyses were conducted in R (R version 3.2.2), using the lme4 package (Bates et al. 2014). We used the same analytic plan as Brocher et al. (2016). We conducted nested hierarchical generalized linear regression models with looks to the object picture relative to the sum of looks to all three pictures as dependent measure. To that end, all data points were included in the analysis as a vector containing the looking time to the object referent and the sum of looking time to the object picture, subject picture, and look-away picture. For example, given a particular time frame of 300 ms, if 90 ms of looks within that frame fell on the object picture, 150 ms on the subject picture, and 50 ms on the look-away picture, the dependent measure for this particular frame and condition would be (90, 290). We opted for this statistical approach because it directly reflects the binomial distribution of the data (i.e. given a particular frame, a participant either looks at a picture of interest, 1, or not, 0), while acknowledging that conditions might also differ with respect to the looks that did not fall on the target object picture (by including the sum of looks to all pictures on the screen in the dependent variable).

We modeled the influence of the two predictors information status (inferred or brand-new) and definiteness marking (definite or indefinite article) and their interaction on mean fixation times within a time bin. Both predictors were sum-coded prior to analyses. Models were then fitted for each time frame individually. They included by-participants and by-items intercepts as well as by-participants and by-items random slopes. The random slopes for the two earlier time bins (200–500 ms, 500–800 ms) included the linear combination of information status and definiteness marking in the by-participants slope and definiteness marking in the by-items slope. For the two later time bins (800–1100 ms, 1100–1400 ms), both random slopes included the linear combination of information status and definiteness marking. *P*-values for the analysis of fixation times were corrected for multiple testing, applying the Bonferroni procedure (for five comparisons) and corrected *p*-values will be reported for each time frame.

The time course of the proportion of looks to the picture of the object referent is plotted in Figure 3. Results of the inferential statistics are summarized in Table 2. Because predictors were sum-coded, the intercepts reflect the grand average of looking time across all four conditions. The coefficients present deviations from that average. A positive coefficient for definiteness marking reflects an increase and a negative value a decrease in looking time to the object picture in the definite conditions. Likewise, for information status, a positive coefficient reflects an increase and a negative value a decrease in looking time to the object picture in the inferred conditions.
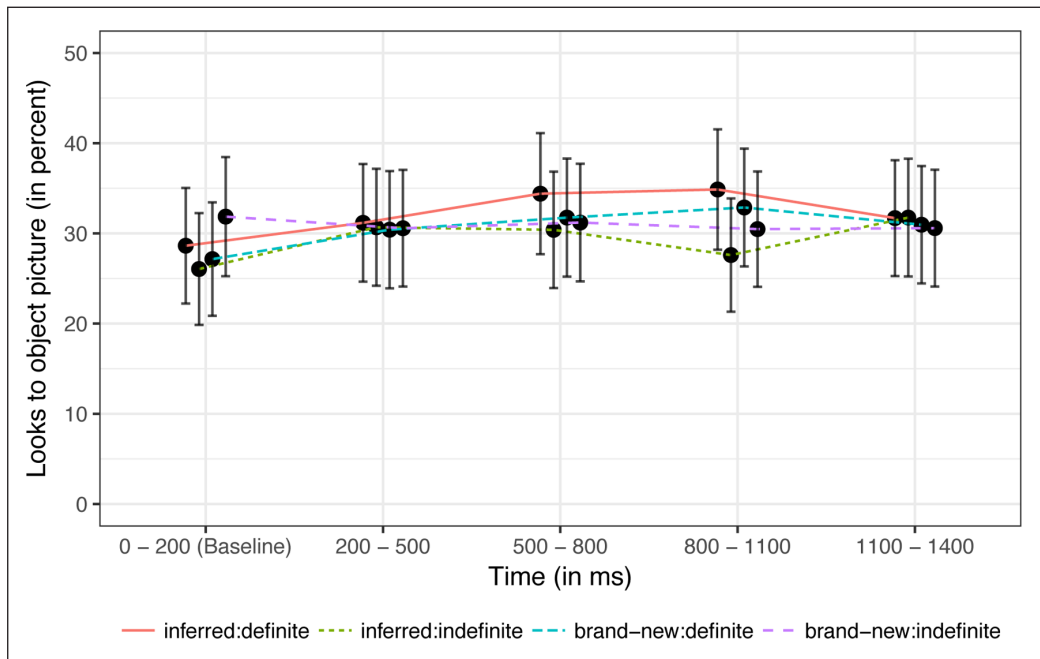
Figure 3: Looks to the picture of the object referent (in%) along with standard errors per time frame and condition; the beginning of the x-axis marks the onset of the pronoun; the numbers represent ms post pronoun onset; inferred = referents with inferred concepts; brand-new = referents with brand-new concepts; definite = noun phrases with definite article; indefinite = noun phrases with indefinite article.

Table 2: Inferential statistics for the mean fixation time data of Experiment 1.

Time (in ms)	Main Effect/Interaction	b	SE	z	
200–500	Intercept	−2.41	0.30	−8.00	**
	Definiteness marking	0.19	0.38	0.51	
	Information status	0.17	0.37	0.45	
	Definiteness marking × Information status	0.09	0.37	0.25	
500–800	Intercept	−2.14	0.30	−7.07	**
	Definiteness marking	0.33	0.27	1.21	
	Information status	−0.06	0.27	−0.21	
	Definiteness marking × Information status	−0.07	0.02	−3.18	*
800–1100	Intercept	−2.00	0.26	−7.64	**
	Definiteness marking	0.55	0.34	1.65	
	Information status	0.19	0.24	0.81	
	Definiteness marking × Information status	0.14	0.02	6.43	**
1100–1400	Intercept	−2.44	0.32	−7.72	**
	Definiteness marking	−0.07	0.38	−0.18	
	Information status	−0.53	0.42	−1.25	
	Definiteness marking × Information status	−0.12	0.75	−0.16	

Note: Presented numbers reflect logarithmic odds. The intercept reflects the grand average of logits across all conditions and the coefficients reflect deviations from that average. Positive values mean that the likelihood of fixating the object picture increased; negative values mean that the likelihood of fixating the object picture decreased. For definiteness marking, positive values reflect an increase in looks and negative values a decrease in looks to definite-marked referents. For information status, positive values reflect an increase in looks and negative values a decrease in looks to inferred referents. Definiteness marking = definiteness marking on object noun phrase (definite or indefinite article), Information status = object referent's information status (inferred or brand-new). Bonferroni-corrected significance levels: *$p < .01$, **$p < .001$.

As can be seen in Figure 3, while mean looking times are somewhat disparate within the 200 ms within pronoun encounter, conditions start to diverge at 500 ms post pronoun onset. Although there is a general tendency for pictures of definite referents to attract more looks than pictures of their indefinite counterparts, this difference seems stronger for inferred than brand-new referents. The difference between inferred definite and inferred indefinite referents is most pronounced between 500 ms and 1100 ms post pronoun onset.

Results of the regression models confirm this observation. The two models fitted for the time frames 500 ms–800 ms and 800–1100 ms, respectively, revealed a significant Information status × Definiteness marking interaction. Resolving this interaction for the 500 ms–800 ms frame confirmed that inferred definite referents attracted more looks than inferred indefinite referents, $b = 0.50$, $SE = 0.01$, $t = 3.63$, $p < .001$, with no significant difference between brand-new referents, $b = 0.61$, $SE = 0.62$, $t = 0.98$, $p = .652$ (p-values Bonferroni-corrected for two comparisons). Resolving the interaction for the 800 ms–1100 ms frame revealed the same pattern. Inferred definite referents continued to be fixated more than their indefinite counterparts, $b = 1.50$, $SE = 0.61$, $t = 2.46$, $p = .028$. For brand-new referents, again, no reliable difference was obtained, $b = 0.74$, $SE = 0.51$, $t = -1.44$, $p = .302$ (p-values Bonferroni-corrected for two comparisons). We also fitted a model for the time frame that included the very onset of the pronoun plus the subsequent 200 ms to test for baseline effects. There were no statistically reliable differences between definite and indefinite or inferred and brand-new referents, nor was there an interaction, all $zs < 1$, all $ps > .6$.

2.3 Discussion

Experiment 1 replicates the data reported in Brocher et al. (2016) and renders it unlikely that their results were due to the testing of different sources of uniqueness in the inferred and brand-new conditions, namely anchor-triggered and article-triggered uniqueness. Data from Experiment 1 are also not compatible with the key assumptions of accessibility scales, which predict definite descriptions to be generally more accessible than indefinite descriptions, and Functional Centering Theory, which predicts inferred referents to be generally more accessible than brand-new referents.

Instead, our data suggest that comprehenders used both the information status of a referent as well as the definiteness marking of the associated noun phrase to integrate specific pragmatic inferences at the sentence level, i.e. at a point in discourse at which the referent had already been accessed and integrated.

This is in line the Dual-Process Activation Model as well as with more theoretical approaches in the field (Karttunen 1969; Kamp 1981; Heim 1982; Farkas 2002): In contexts where a noun phrase and its associated concept are brand-new, both the definite and indefinite article lead to the activation of a discourse referent. The definite article leads to referent activation (or identification) through a uniqueness presupposition. The indefinite article, on the other hand, leads to the activation of a discourse referent through the combination of its primary function to express existence together with a uniqueness implicature, which then leads to the referent. As a consequence, no significant differences were obtained when a referent needed to be assigned to a later occurring pronoun, because a referent was equally activated in both conditions (brand-new definite and brand-new indefinite).

Now, the referential choice prompted by the article and the additional pragmatic inferences differ in contexts where the concept of a referent had been pre-activated by an anchor. The pre-activated concept provides knowledge common to both the speaker and hearer and thereby restricts the choice of which referents to activate. Under these conditions, the definite article leads to the restriction that one unique element needs to be

accessed from the pre-activated set of elements, while the indefinite article expresses non-uniqueness and does not activate a particular referent, but rather acknowledges the existence of a set of referents.

For example, in the context of a gym, the noun phrase *a trainer* simply affirms that there are typically trainers at a gym, without pointing the hearer to the identification of a specific trainer. The inferred indefinite referent is then best represented by a role (Zwarts 2014) and its referential properties similar to the properties of bare nouns and weak definites (Carlson et al. 2013). It is this very assumption of the Dual-Process Activation Model that explains the observed differences between inferred indefinite and brand-new indefinite referents. Only for the latter, but not the former, do hearers infer that there is a referent that can be uniquely identified.

Note that one might argue that the experimental design we used favored referents of definite over referents of indefinite descriptions. That is, one might argue that participants linked the pronoun to the picture of the object referent more quickly when that referent could be uniquely identified than when it could not because the corresponding picture showed one instance of, for example, a trainer. Although generally plausible, we believe that a direct link between picture and definiteness marking has not (significantly) affected our results. First, if presenting a picture of a single person made definite noun phrases more quickly available than indefinite noun phrases, we should have found more looks to the picture of definite than indefinite noun phrases also in the brand-new conditions, which is not what we observed. Second, while it is possible that participants' gazes moved more quickly to the picture of the object referent at article encounter when that article was *the* rather than *a,* the dependent measure in Experiment 1 was the mean looking time at pronoun encounter, which was considerably later in the stories than the onset of the object noun phrase.

Finally, our data do not allow us to determine whether the observed differences in pronoun resolution between subject and object antecedent were due to differences in next mention bias, differences in pronoun preference, or both. Considering that the preference of specific referring expressions has mostly been associated with grammatical and thematic role (as well as recency, see Arnold 2010 for a brief review), and also considering that all our target referents appeared in (non-preferred) object position, we suspect that our results are most likely due to differences in next mention bias, rather than to differences in pronoun preference.

3 Experiment 2: Noun retrieval and integration

In Experiment 1 we tested whether the interaction of concept activation and referent activation leads comprehenders to integrate specific pragmatic inferences after having accessed and integrated the associated descriptive noun phrase. In Experiment 2, we tested for potential contributions of concept and referent activation to referent management at the very point the referent is accessed and integrated for the first time in discourse. Experiment 2, which used ERPs, then allowed us to investigate concept and referent activation at (a) article encounter (definite vs. indefinite article) and (b) noun encounter (inferred concept vs. brand-new concept).

Experiment 2 should be revealing in two respects. First, the Dual-Process Activation Model states that both the article and the descriptive part of the noun of a noun phrase contribute to referent management. The article informs a comprehender whether or not the referent can be uniquely identified, which we take to reflect referent activation, and the descriptive part of the noun informs the comprehender whether or not the concept has already been activated, which we take to reflect concept activation. Second, for the two indefinite conditions, the model predicts that comprehenders derive a uniqueness

implicature for brand-new referents and a non-uniqueness implicature for inferred referents. However, these processes are predicted to appear at the sentence level, not at the level of the noun phrase. If this were correct, we should find a clearer grouping of conditions than in Experiment 1. In other words, if the interaction of information status and definiteness marking reported for Experiment 1 was due to the integration of specific pragmatic inferences at the sentence level, no such interaction should be found in Experiment 2, which tested processes at the noun phrase level.

In line with previous studies, we predicted that definite and indefinite articles should differ in the strength of a negative deflection in the ERP signal. The difference in negativity has been taken as evidence that the definite article leads a comprehender to search previous context for a matching referent (Schumacher 2009), which is in line with the assumption about a uniqueness presupposition. The indefinite article, on the other hand, leads a comprehender to expect new information (Anderson & Holcomb 2005).

For referent access and integration at the subsequent noun, we predicted differences in the size of the N400, which has been associated with semantic processing, and differences in the size of late positivities, which has been associated with integration. We focused on the N400 and late positivities because these two components have often been linked to information access and integration (see e.g., Brouwer et al. 2012): The more accessible the semantic and conceptual information of a word or phrase is, the smaller the N400 should be. Likewise, the more easily a word or phrase can be integrated in a context, the smaller the late positivities should be. We expected referents with pre-activated concepts to be retrieved and integrated more easily and thus to yield smaller N400s and smaller late positivities than referents whose concepts are brand-new.

There are massive amounts of data available in the field that identify various components in the ERP signal, including language related markers such as the N400 and the P600 or late positivities (for reviews, see Kutas & van Petten 1994; Kutas & Federmeier 2011; Brouwer et al. 2012). Although there is an ongoing debate about what the N400 and late positivities precisely reflect, the N400 is often associated with more lexical, semantic, or conceptual processing, while late positivities are often linked to processes involving information integration and context updating (cf. Brouwer et al. 2012).

More recently, ERPs have been used to investigate discourse comprehension in general, and referent management in particular (for a review, see van Berkum 2004). A number of studies have looked at anaphora resolution, both for descriptive noun phrases (van Berkum et al. 1999; van Berkum et al. 2003; Streb et al. 2004; Burkhardt 2006; Nieuwland et al. 2007; van Berkum et al. 2007; Nieuwland & van Berkum 2008; Schumacher 2009; Hung & Schumacher 2012; Schumacher & Hung 2012) and pronouns (Osterhout & Mobley 1995; Osterhout 1997; Harris et al. 2000; Streb et al. 2004; van Berkum et al. 2004; Nieuwland & van Berkum 2006; Ferretti et al. 2009; Schumacher et al. 2015).

In the context of referential processing, the N400 and late positivities have also received some attention (Streb et al. 2004; Burkhardt 2006; 2007; Ferretti et al. 2009; Schumacher 2009; Hung & Schumacher 2012; Schumacher & Hung 2012). A group of studies that are most relevant to our Experiment 2 are Burkhardt (2006), Schumacher (2009), Schumacher & Hung (2012), and Hung & Schumacher (2012). Burkhardt (2006) constructed small discourses and manipulated a referent's information status by including given, inferred, and brand-new referents. She found that brand-new referents elicited larger N400s than given and inferred referents, respectively. She also found larger late positivities for brand-new referents compared to given, but not to inferred referents. Thus, inferred referents fell between given (similarly large N400) and brand-new referents (similarly large late positivities).

Schumacher (2009) replicated and extended these findings. She manipulated a referent's information status (given, inferred, or brand-new) and also crossed information status with definiteness marking, such that referents were either denoted by a noun phrase including a definite or indefinite article. While replicating the general pattern of results reported in Burkhardt (2006), Schumacher (2009) also found a left anterior negativity in response to the definite over the indefinite article (but see Anderson & Holcomb 2005 for the reversed pattern). Furthermore, given referents that were definite-marked led to a much smaller late positive shift than referents of the other conditions. Notably, contrasting given and brand-new and given and inferred conditions, respectively, Schumacher & Hung (2012) and Hung & Schumacher (2012) showed that the observed differences in the N400 survived positional shifts within a sentence, while the late positivities were sensitive to topic vs. non-topic position.

Taken together, data by Burkhardt (2006), Schumacher (2009), Schumacher & Hung (2012), and Hung & Schumacher (2012) suggest that both a referent's information status and the definiteness marking at the associated noun phrase can affect ERPs when a referent is newly introduced into discourse. Differences in the strength of negativity elicited at the articles were taken as evidence that definite, but not indefinite, articles serve as pointers to previous context. This assumption is fully compatible with the claim that the definite article leads to referent identification through a uniqueness presupposition.

Differences in the N400 on the noun seem to reflect differences in the ease with which a concept can be accessed and linked to the preceding context, thereby establishing coherence (given < inferred < brand-new), and this effect is robust against variability in topic-hood. Differences in late positivities, on the other hand, seem to indicate processing costs associated with referent integration or, as Schumacher (2009) argues, with discourse updating. Crucially, these processing costs seem to vary with topic-hood: In topic position, no differences in ERPs as a function of information status are obtained, while in non-topic positions, concept pre-activation seems to ease integration and updating. Note that differences in late positivities due to differences in ease of integration have also been observed in studies on metonymy and metaphor processing (Schumacher 2011; Weiland et al. 2014; Bambini et al. 2016).

Now, the idea about coherence-driven modulations in the N400 and (discourse) updating-driven modulations in late positivities is compatible with the Dual-Process Activation Model and, more specifically, with the notion of concept activation. Referents with pre-activated concepts are predicted to be accessed more easily than referents with brand-new concepts. Referent integration and discourse updating are also predicted to be easier when the concept of the referent has already been activated than when it is brand-new, at least to the extent that other processes, such as topic-related ones, do not override these integration and updating processes (Hung & Schumacher 2012; Schumacher & Hung 2012).

Nevertheless, there are a few shortcomings in Schumacher's (2009) study, which we need to address before we can match Schumacher's assumptions with the assumptions of the Dual-Process Activation Model. First, in the inferred conditions, it is not clear whether Schumacher (2009; see also Burkhardt 2006), only used referents that could be uniquely identified by virtue of anchor encounter (anchor-triggered uniqueness) or whether some referents could only be uniquely identified through encounter of the definite article (article-triggered uniqueness). The example stimulus provided in the text suggests that Schumacher (also) tested anchor-triggered uniqueness (*presentation… speaker*). This might have affected the amplitude of the N400, as lexically unique referents might be particularly strongly associated with their contexts and therefore exaggerate the difference to the brand-new referents. Second, Schumacher's brand-new and inferred conditions differed

in the number of referents that appeared in the context sentence. In the brand-new conditions, two referents were introduced. In the inferred conditions, only one referent was introduced. Additionally, both conditions also included a pronoun before critical noun phrase presentation, which increased the complexity in referent tracking. Indeed, Arnold & Griffin (2007) have shown that a referent's prominence and accessibility can vary with the number of referents that are introduced in the discourse.

Third, all critical referents in Schumacher's experiment appeared in subject position and were the topic of the sentence. Thus, the reported results were perhaps affected by differences in the ease with which a definite or indefinite expression could be retrieved and integrated in a more or less canonical position (see Hung & Schumacher 2012 and Schumacher & Hung 2012, who tested given vs. brand-new and given vs. inferred conditions, respectively). Finally, given and inferred referents of the indefinite conditions in Schumacher (2009) were used somewhat infelicitously. The full crossing of information status and definiteness marking led to short stories including *a speaker* in the first and *a speaker* in the second sentence (given condition), and *a talk* in the first and *a speaker* in the second sentence (inferred condition). In the former case, the two instances of *speaker* cannot be judged as coreferential, as otherwise the definite article should have been used in the second occurrence. In the latter case, it seems odd to use an indefinite description for a lexically unique referent (a speaker of a talk).

Our Experiment 2, then, addressed the above-discussed shortcomings. The predictions were as follows: For the article (*a/the*) preceding the critical noun (e.g., *trainer*), conflicting results have been reported in the literature. While, Schumacher (2009) found larger negativities for definite than indefinite articles, the exact opposite was reported in Anderson & Holcomb (2005). Thus, it was somewhat unclear what to predict for our articles despite a general difference in negativity between definite and indefinite articles. According to the theoretical literature and the Dual-Process Activation Model, the function of the definite article is to signal unique identifiability, while the function of the indefinite article is to express an existential entailment, which, depending on the context, might or might not trigger unique identifiability at the sentence level (see Experiment 1, also Heim 1991; 2011).

For the nouns and again following the Dual-Process Activation Model and previous studies, we expected information status to significantly affect the size of the N400. In particular, we expected inferred referents to elicit smaller N400s than brand-new referents because the concept of the former but not the concept of the latter should already be activated at noun encounter. This, in turn, should ease referent access. With respect to late positivities, we predicted smaller amplitudes for inferred than for brand-new referents, provided that the availability of inference relations at noun encounter indeed eases the integration of a noun in canonical, non-topic position (Burkhardt 2007; Schumacher & Hung 2012). If, on the other hand, concept pre-activation does not ease the integration of a referent in discourse, even when the associated noun phrase appears in non-topic position, we expect similarly large late positivities for inferred and brand-new referents (Burkhardt 2006; Schumacher 2009).

Finally, the Dual-Process Activation Model predicts that, while the definite and indefinite article set the stage for uniqueness and non-uniqueness via identification vs. existence, unique identifiability of the associated referent is computed at the sentence level. More specifically, it is computed at the level at which the comprehender forms the proposition and semantic representation of a sentence. If this were correct, definiteness marking should not greatly affect noun retrieval or integration per se, as participants would not compute referent uniqueness or non-uniqueness before the end of the sentence. Note that

such an outcome would not only be in line with the findings reported in Schumacher (2009). It would also make sense at a more conceptual level. It is likely that a comprehender draws specific inferences associated with a noun phrase after that noun phrase has been processed, as, at least in German, there are various ways to modify the noun postnominally, e.g., with a relative clause or a prepositional phrase. Thus, a comprehender might wait until the end of a sentence to see whether more information will be provided that may or may not further restrict the set of potential referents associated with the present noun phrase.

Note that, just like for Experiment 1, we can again derive some predictions from theories using accessibility scales or hierarchies (Ariel 1988; Gundel et al. 1993). In analogy to the predictions for Experiment 1, accessibility scales expect definite descriptions to be overall more accessible than indefinite descriptions. Thus, noun phrases with a definite article should yield smaller N400s (easier retrieval) and/or smaller late positivities (integration) than noun phrases with an indefinite article. In addition, we should not observe significant differences between noun phrases with inferred and noun phrases with brand-new concepts.

3.1 Method

3.1.1 Participants

Twenty-four students of the University of Cologne participated in the experiment in exchange for monetary compensation (EUR 8 per hour). All participants were monolingual speakers of German and no participant reported any history of neurological or psychiatric disorders. The study was approved by the ethics committee of the DFG.

3.1.2 Materials

Experiment 2 used materials that were similar to the materials of Experiment 1, and all materials were again in German. However, in Experiment 2, brand-new conditions were created by changing the context sentence, not the noun in object position. In other words, all experimental conditions used the very same direct object referent (e.g., *trainer*), while the context sentence varied between inferred and brand-new conditions. This was done because using the same noun across the four conditions of interest sidesteps the need for tedious material norming. Second, we omitted the final sentence of each experimental (and filler) story, which, in Experiment 1, included the ambiguous pronoun. An example set of stimuli is presented in Table 3. All stories in their original German can be accessed in the Online Supplement, Appendix A. Note that we included an additional eight items in the set of materials, yielding a total of 40 experimental quadruples by fully crossing information status (inferred or brand-new) and definiteness marking (definite or indefinite article).

In half of the experimental short stories, the target object referent was preceded by an unrelated context sentence (*modern gallery… trainer*). In the other half, object referents were preceded by a sentence containing an anchor that activated their concept (*gym…*

Table 3: Sample experimental materials for Experiment 2.

(1a) The gym was very crowded, as always.	
(1b) The new installation at the modern gallery was very crowded, as always.	
(2) Philip stared at _____	(a) the trainer next to the window.
	(b) a trainer next to the window.

Note: Materials are translated from German. The context sentence (1) was manipulated to yield inferred (1a) and brand-new conditions (1b); the referent in direct object position in sentence (2) was manipulated to yield definite (2a) and indefinite descriptions (2b).

trainer, see typicality norming below). Object referents were again either realized by a definite or indefinite noun phrase. Again, we ensured that the concept of referents of the inferred conditions was more strongly associated with their contexts than the concept of referents of the brand-new conditions by conducting a typicality norming study with 36 native German speakers (see Experiment 1 for details). Results confirmed that brand-new referents were only weakly associated with their contexts. The mean typicality score for these referents was 2.53 (*SE* = 0.19, range: 1.1–4.3), compared to 5.72 (*SE* = 0.17, range: 3.6–6.9) for the inferred referents. The difference was statistically reliable as indicated by a planned paired *t*-test (two-tailed), $t(35) = 11.9$, $p < .001$.

To determine the overall plausibility of our short stories, we additionally conducted a second norming study, asking a total of 24 participants how good or plausible of a beginning of a story they thought a presented story fragment was. We constructed two lists, each of which contained 80 two-sentence fragments. Half of these fragments were the stories used in the main experiment. The other half were story fragments that were of somewhat low plausibility. These less plausible stories were very similar in structure to the experimental stories (e.g., *The sun was shining the whole day. Lucas saw a fox jumping from one cloud to another*). Of the 40 experimental stories used in a list, 20 were of the inferred and 20 of the brand-new condition. All items were used in their indefinite condition. Stories were distributed across the two presentation lists such that each item appeared in both conditions without any repetition of items within a list.

Participants judged the plausibility of a fragment by providing a score between 1 for "not plausible at all" and 7 for "very plausible." Stories of the inferred conditions were judged to be more plausible than the stories of the brand-new conditions. This is predicted, considering that inferred referents are more expected than brand-new referents. Stories with inferred referents received a mean plausibility score of 5.1 (*SE* = 0.4). Stories with brand-new referents received a mean plausibility score of 4.3 (*SE* = 0.4). In comparison, less plausible filler stories received a mean plausibility score of 2.2 (*SE* = 0.3).

The experiment comprised a total of 40 experimental short stories as well as 100 filler stories. Filler stories were again similar in structure and length to the experimental stories and we again used lexical ambiguities and attachment ambiguities as distractors. All materials were distributed across two presentation lists, such that each participant saw each item twice, once in the inferred and once in the brand-new condition, and both in the same definiteness condition. Thus, item repetition led to only minimal overlap in material content, as the context sentence was different across repetitions (see Table 3). All stories were followed by a comprehension question, which, for experimental items, always targeted the context sentence. For fillers, comprehension questions also mostly targeted the first sentence of stories. Half of these questions required a "yes"-response, half a "no"-response.

3.1.3 Procedure

Participants sat in a sound-attenuating booth and were asked to read the presented short stories for comprehension. All stories were presented visually word by word, such that individual words appeared at the center of a computer screen. Words were presented in yellow letters against a blue background. Each trial started with the presentation of three asterisks to prepare participants for the next story. After that, the first word of the story appeared for 400 ms with an interstimulus interval between words of 100 ms, yielding a SOA of 500 ms. After presentation of the final word of a story and with a delay of 500 ms, a comprehension question appeared. Comprehension questions were presented as a whole. Participants were asked to pay close attention to the stories to be able to correctly

answer subsequent comprehension questions by pressing either a "yes" or "no" button on a response box. Overall accuracy was 92%. The experimental session was preceded by a practice session consisting of four short stories.

3.1.4 Recording and preprocessing

EEGs were recorded from 26 Ag/AgCl scalp electrodes, which were mounted in an elastic cap. Electrode distribution corresponded to the standard 10–20 system for electrode placement. We recorded from the following electrodes: Fz, FCz, Cz, CPz, Pz, and POz for midline electrodes, and FP1/2, F3/4, F7/8, FC3/4, FT/8, C3/4, T/8, CP5/6, P3/4, P7/8, O1/2 for left-lateralized and right-lateralized electrodes, respectively. Recordings were referenced to the left mastoid and, in an offline procedure, re-referenced to linked mastoids. To be able to detect ocular artifacts, we monitored both horizontal and vertical eye movements through two sets of additional electrode pairs. For detection of horizontal eye movements, electrodes were placed at the outer cantus of the left and right eye, respectively. For detection of vertical eye movements, electrodes were placed above and below each participant's left eye. Electrode impedances were kept below 5 kΩ. EEG signals were recorded with a sampling rate of 250 Hz. All channels were amplified using a BrainAmp amplifier.

After recording, all data were filtered using a bandpass filter of 0.3–20 Hz. We then extracted epochs for all words of interest (direct object article; direct object noun) and all participants and conditions individually. For the object article and the object noun, we calculated average EEG amplitudes for 1200 ms within stimulus presentation. Epochs that exceeded ± 75 μV were automatically rejected. All participants provided more than 80% useable data points and the overall rejection rate for the data was 7.2%.

3.1.5 Data analysis

Statistical analyses were conducted in R (R Core Team 2015) using the ez-package (Lawrence 2013). In the region of interest (ROI) analysis, we conducted a 2 (information status: inferred or brand-new) $\times$ 2 (definiteness marking: definite or indefinite article) $\times$ 4 (ROI: left anterior, right anterior, left posterior, or right posterior) Analysis of Variance (ANOVA). We also performed statistical analyses on the midline electrodes as supplemental analyses. Here, we conducted a 2 (information status: inferred or brand-new) $\times$ 2 (definiteness marking: definite or indefinite article) $\times$ 6 (Electrode: Fz, FCz, Cz, CPz, Pz, or POz) ANOVA. Whenever the numerator exceeded one degree of freedom, we applied Huynh-Feldt adjustments. Corrected *p*-values will be presented with these adjustments.

3.2 Results

Analyses were conducted for various windows of interest. All windows were time-locked to the beginning of the respective word of interest, i.e. to the onset of the article and noun, respectively. For the article, we conducted an ANOVA on mean amplitudes in the 300 ms–700 ms window post article onset (Anderson & Holcomb 2005; Schumacher 2009). For the noun, we performed separate ANOVAs for mean amplitudes in the N400 window, ranging from 300 ms to 500 ms post noun onset, and the late positivity window, ranging from 500 ms to 800 ms post noun onset. All windows of analysis are based on previous studies in the field and were determined prior to data collection.

ERPs on article. Grand averages of the ERPs time-locked to article onset (*a/the*) are depicted in Figure 4. The output of the corresponding ANOVA is presented in Table 4. Results of the supplemental analysis on midline electrodes can be found in the Online Supplement, Appendix B. Inspection of Figure 4 reveals that definite articles yielded
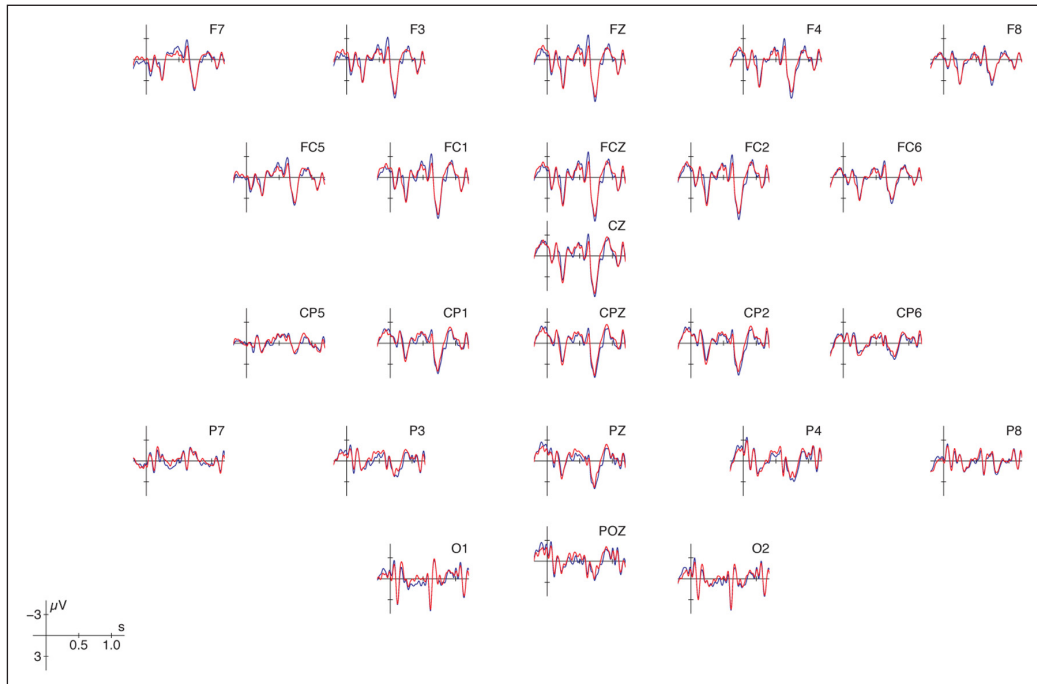
Figure 4: Grand averages for ERPs time-locked to article encounter. Averages are provided for the definite (blue) and indefinite article (red).

**Table 4:** Inferential statistics for analysis of ERPs at article encounter (300 ms–700 ms).

Main Effect/Interaction	DFs	*F*	*p*
Definiteness marking	1, 23	0.01	.971
ROI × Definiteness marking	3, 69	8.60	<.001

Note: Definiteness marking = definiteness marking on object noun phrase (definite or indefinite article); ROI = region of interest (frontal left, frontal right, posterior left, posterior right); DFs = degrees of freedom.

larger negativities than indefinite articles in frontal channels, while indefinite articles led to larger negativities than definite articles in posterior electrodes. Both these observations pertain more to the electrodes on the left than to the electrodes on the right side of the scalp. The ANOVA, then, registered a significant ROI × Definiteness marking interaction. Follow-up analyses confirmed that definiteness marking was significant in the left frontal, $F(1, 23) = 5.41, p = .029$, and left posterior ROI, $F(1, 23) = 4.77, p = .039$.

ERPs on noun. Grand averages of ERPs time-locked to noun onset (*trainer*) are provided in Figure 5. Results of the statistical analyses on N400s and late positivities are provided in Table 5. Results of the analyses on central electrodes can again be accessed in Appendix B of the Online Supplement. As predicted, and replicating previous studies, we found overall smaller N400s for inferred than for brand-new referents, although it is important to note that visual inspection of Figure 5 suggests that this difference was mainly driven by brand-new indefinite referents. Nevertheless, only the main effect of information status reached statistical significance. In addition, we found smaller positivities for inferred than brand-new referents, which is compatible with previous findings showing that concept pre-activation can ease referent integration in non-topic positions (Hung & Schumacher 2012; Schumacher & Hung 2012). Information status interacted with ROI. Resolution of the ROI × Information status interaction revealed that the effect of information status was only reliable in the right posterior ROI, $F(1, 23) = 4.38, p = .048$.
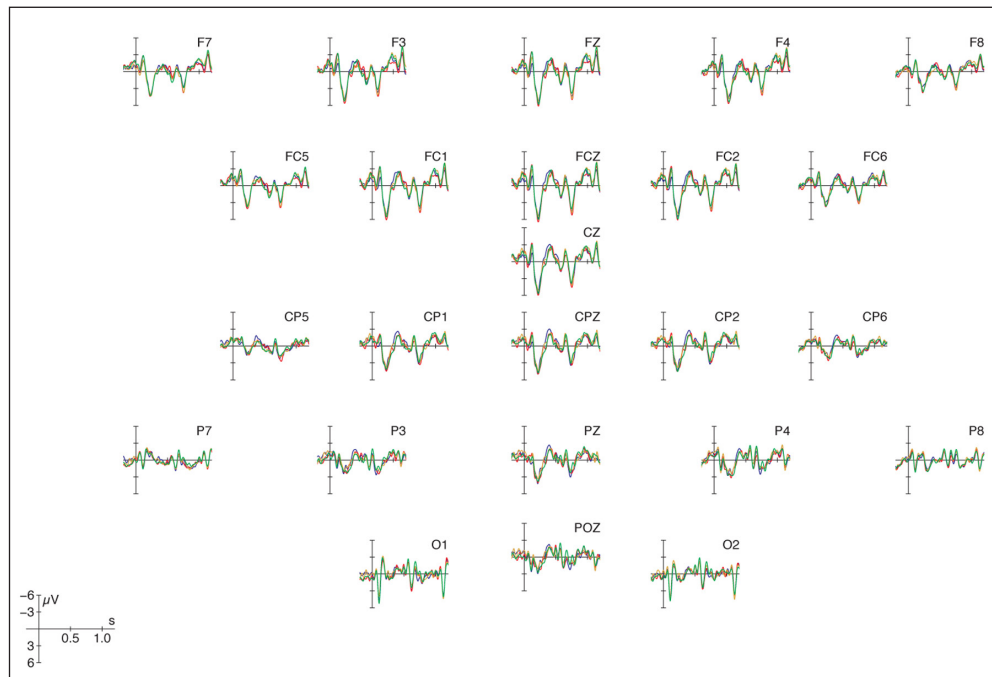
Figure 5: Grand averages for ERPs time-locked to noun encounter. Averages are provided for inferred definite noun phrases (green), inferred indefinite noun phrases (yellow), brand-new definite noun phrases (red), and brand-new indefinite noun phrases (blue).

Table 5: Inferential statistics for analysis of ERPs at noun encounter.

Main Effect/Interaction	DFs	300 ms–500 ms		500 ms–800 ms	
		F	**p**	**F**	**p**
Definiteness marking	1, 23	2.18	.154	0.02	.894
Information status	1, 23	6.09	.022	0.46	.502
Definiteness marking × Information status	1, 23	1.22	.281	0.74	.398
ROI × Definiteness marking	3, 69	0.94	.394	0.40	.678
ROI × Information status	3, 69	0.31	.742	3.65	.042
ROI × Definiteness marking × Information status	3, 69	0.92	.404	0.05	.942

Note: Definiteness marking = definiteness marking on object noun phrase (definite or indefinite article); Information status = information status of referent (inferred or brand-new); ROI = region of interest (frontal left, frontal right, posterior left, posterior right); DFs = degrees of freedom.

3.3 Discussion

Data from Experiment 2 are compatible with the various claims of the Dual-Process Activation Model and broadly line up with previous studies on noun phrase processing. As predicted, both definiteness marking, which we link to referent activation, and information status, which we link to concept activation, affected the very introduction of a new discourse referent with a descriptive noun phrase.

Definite articles elicited larger negativities than indefinite articles in frontal electrodes on the left side of the scalp, replicating Schumacher (2009), while indefinite articles elicited larger negativities than definite articles in posterior electrodes also located at the left side of the scalp, which replicates Anderson & Holcomb (2005). Thus, the data of Experiment 2 are compatible with both Schumacher (2009) and Anderson & Holcomb (2005). We argue in line with these studies that the larger negativity for definite rather than indefinite articles in frontal electrodes reflects the fact that the definite, unlike

the indefinite, article instructs the comprehender to search for an individual referent in previous context (Schumacher 2009). The larger negativity for the indefinite compared to the definite article, in contrast, reflects the fact that the indefinite unlike the definite article leads the comprehender to anticipate new information, more specifically a new discourse referent. What is important with respect to the notion of referent activation, as is reflected in the Dual-Process Activation Model, is that only the definite article initiates a process of referent identification.

Turning to the ERPs elicited at the nouns, we found that inferred noun phrases were accessed with more ease than their brand-new counterparts, as indicated by significant differences in N400 magnitude. This finding is fully compatible with Burkhardt (2006; 2007), Schumacher (2009), and Schumacher & Hung (2012), as well as with the idea that a noun's information status can be used to establish coherence. Our data also show that the pre-activation of a referent's concept leads to easier referent integration in discourse. This finding adds to the evidence that the availability of an inference relation (e.g., between GYM and TRAINER) affects referent integration, at least when the noun phrase of that referent appears in canonical, non-topic position (Burkhardt 2007; Schumacher & Hung 2012).

Finally, the retrieval and integration of the noun in object position were unaffected by definiteness marking. These findings, which corroborate the data reported by Schumacher (2009), suggest that comprehenders did not compute referent uniqueness vs. non-uniqueness when processing the noun of the descriptive noun phrase. Instead, and as we proposed in our discussion of the Dual-Process Activation Model above, uniqueness and non-uniqueness of a referent seem to be fully computed via presupposition and implicature at a sentence level. When accessing and integrating the critical noun phrase in our stories, participants were still in the process of generating the proposition of the respective sentence. Thus, at this point, they seem not to have derived the associated presuppositions and implicatures associated with the referents.

4 General discussion

We conducted two experiments to investigate effects of a referent's information status, which we associate with concept activation, and definiteness marking, which we associate with referent activation, on referent management. More specifically, we investigated how the contextually induced information status of a noun phrase interacts with the functions of the article within that noun phrase. In both experiments, participants were presented with short stories that introduced two human referents, one in subject and one in direct object position. While the referent in subject position was always a proper name, the referent in object position was a descriptive noun phrase – either definite (*the* trainer) or indefinite (*a* trainer) – whose concept (e.g., TRAINER) could either be inferred from preceding context (*gym… trainer*) or not (*modern gallery… trainer*).

In Experiment 1, we used a visual world eye tracking experiment testing referent accessibility during ambiguous pronoun resolution. We were interested in the question of whether comprehenders integrate specific pragmatic inferences associated with referent management at the sentence level. We found that the referent in object position was a better competitor to the referent in subject position when it could be inferred and was definite-marked than when it could be inferred and was indefinite marked. For brand-new referents, we found no reliable differences between definite and indefinite noun phrases. These data replicate Brocher et al. (2016) and provide further evidence that definite and indefinite articles differently affect the re-mentioning of inferred and brand-new referents.

The Dual-Process Activation Model, which we discussed in the introduction and reproduce in Figure 6, accounts for the interaction of concept activation and referent activation
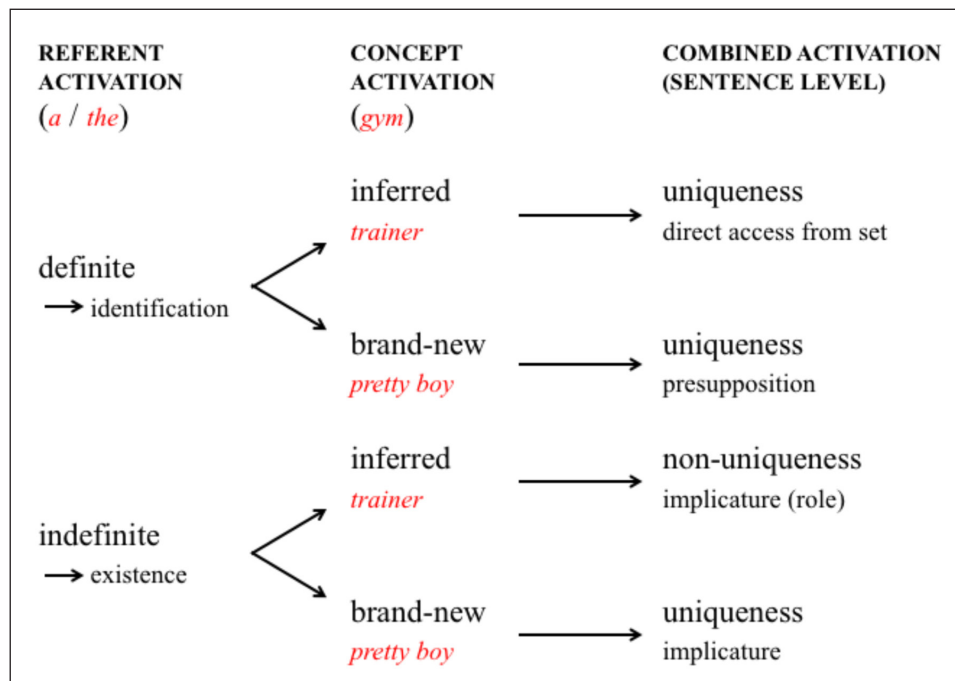
Figure 6: Illustration of the Dual-Process Activation Model.

at referent re-mention as follows: For inferred referents, the concept is pre-activated by the concept of an anchor in discourse. Thus, the set of potential elements is generally more easily accessible to a hearer than elements associated with brand-new concepts and the definite and indefinite article can operate on the pre-activated set of potential referents. The definite article signals that there is just one element, such that that element can be directly accessed from the set. In contrast, the indefinite article merely asserts (or acknowledges) that the pre-activated set is non-empty. It then contributes a non-unique-ness implicature. Therefore, an inferred indefinite noun phrase does not provide a par-ticular referent. This made these expressions particularly poor competitors to the subject referents in Experiment 1, as an individual referent needed to be activated at pronoun encounter.

Turning to the re-mentioning of referents with brand-new concepts, the Dual-Process Activation Model predicts that there is no clear difference between definite and indefinite marked noun phrases at the sentence level. Both the definite and indefinite article lead the comprehender to introduce a referent that can be uniquely identified. For brand-new referents with a definite article, uniqueness comes about through referent identification (prompted by the definite article) and a uniqueness presupposition (after the brand-new concept has been activated, see Figure 6). For brand-new referents with an indefinite arti-cle, uniqueness comes about through an existential entailment (prompted by the indefinite article) and a uniqueness implicature (after the brand-new concept has been activated). To cite an example, regardless of whether we newly introduce *a trainer* or *the trainer* in the context of a modern gallery visit, there seems to be just one trainer in the context. Indeed, Heim (1991) shows that the assumption of uniqueness is a scalar implicature that can easily be overwritten. It is then not surprising that we did not find reliable differences in looking times between brand-new definite and brand-new indefinite referents.[2]

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[2] One reviewer rightly pointed out that it is not clear to what extent, if at all, participants in our exper-iments used the post-modifying prepositional phrase in the test materials (e.g., *next to the window*) to identify an individual referent, in particular in the indefinite conditions. Now, we would like to argue that the prepositional phrase was compatible with both the uniqueness implicature associated with the indefinite and brand-new referents, and the role-like reading associated with the indefinite and inferred

In Experiment 2, an ERP experiment, we tested the Dual-Process Activation Model on noun phrase access and integration. We found differently large negativities for definite and indefinite articles. In more anterior channels, definite articles yielded larger negativities than indefinite articles. This result has been taken as evidence that definite articles lead comprehenders to search the preceding discourse for a matching individual antecedent (Schumacher 2009). This idea is fully compatible with the notion of referent activation in the Dual-Process Activation Model (cf. Figure 6): The definite article functions as an identification maker, while the indefinite article leads to the assertion of referent existence.

In addition, in more posterior channels, we found indefinite articles to yield larger negativities than definite articles, just like Anderson & Holcomb (2005). These authors discuss their finding in light of givenness/expectedness: Definite articles lead listeners/readers to expect old information, while indefinite articles lead to the expectation of new information. In other words, indefinite articles might work more as a warning signal to a comprehender than definite articles, because they suggest that new information is about to follow. This warning characteristic might then lead to the larger negativities for indefinite over definite articles. While this conclusion does not follow from the Dual-Process Activation Model, we do not think that it is not incompatible with it.

Turning to the critical noun (e.g., *trainer*), we found smaller N400s and smaller late positivities for inferred (*gym… trainer*) over brand-new referents (*modern gallery… trainer*). These results are compatible with a number of studies both on referent management (Burkhardt 2006; 2007; Schumacher 2009; Schumacher & Hung 2012) and on the more classical semantic N400 (see Kutas & Federmeier 2011 for a review). The larger late positivities for inferred over brand-new referents are compatible with Burkhardt (2007) and Schumacher & Hung (2012). For example, Burkhardt (2007) found smaller positivities for nouns (e.g., *pistol*) that could be inferred from preceding context (*shot… pistol*) than for both nouns that were probable given an event (*killed… pistol*) and nouns that were induced by preceding context (*found dead… pistol*). Our data also provide additional evidence that differences in late positivities as a function of inferencing can be found in canonical, non-topic positions. For example, Schumacher & Hung (2012) used very similar materials to those in our Experiment 2. They found differently large positivities between given and inferred referents in canonical direct object positions, but not in non-canonical topic positions.

Tying the data from noun processing to the Dual-Process Activation Model, the assumption is that the descriptive content of a new noun (e.g., *trainer*) introduces or activates an associated concept (TRAINER). This concept can be inferred or brand-new. It is inferred when it has been activated by another concept in previous discourse (e.g., GYM activates TRAINER) and brand-new when it has not been activated by another concept (e.g., MODERN GALLERY does not activate TRAINER). We suggest that the contribution of concept activation was attested in differences in the N400 (retrieval) and late positivities (integration) in Experiment 2. The idea is that new discourse referents can more easily be accessed and integrated when their concepts have already been introduced into discourse. This very idea is compatible with the concept of semantic or associative priming, which is

referents. For the indefinite/brand-new condition, the prepositional phrase is likely to create a more local domain such that readers use the prepositional phrase to accommodate the uniqueness implicature. For the indefinite/inferred condition, it is possible that participants integrate the prepositional phrase in the frame they have established at the anchor and the noun, thereby sustaining the role-like reading of the noun. Clearly, more research is needed to investigate the question of whether post-modifying material in a noun phrase can affect the referential choice readers make when processing the noun phrase.

closely related to the N400 (see Kutas & Federmeier 2011 for a review). When the concept of a noun phrase is already available at noun phrase encounter, accessing the associated referent should be easier than when both a concept needs to be activated and a referent then be assigned to that concept. An interesting question for future research is whether the modulation of the N400 we observed in Experiment 2 was indeed due to the priming of lexical information, or whether it involved conceptual knowledge associated with a frame or script linked to the anchor.

We should reiterate that the Dual-Process Activation Model predicts that the interaction of concept and referent activation (i.e. their combined activation) leads to unique referents for all but the inferred indefinite condition. Because this pattern was not revealed by the ERPs measured at the noun, and as we have already pointed out above, it seems that uniqueness through presupposition and implicature are derived at the sentence level. This means that the observed differences in accessibility measured at the pronoun in Experiment 1 resulted from an interaction of the function of the article (referent activation in the Dual-Process Activation Model), the information status of the descriptive noun phrase (concept activation in the Dual-Process Activation Model), and additional pragmatic inferences, which differ for the various conditions tested in the present study. This, we claim, is the most interesting and novel part of the model presented in Figure 6.

5 Conclusion

We provided empirical support for the claim that a referent's information status and definiteness marking not only affect the introduction of a new referent in discourse; they also lead to the integration of pragmatic inferences at the sentence level. Referent activation either signals to the comprehender that a referent can be uniquely identified or it asserts a referent's mere existence. Concept activation either signals to the comprehender that the concept of a noun phrase has already been part of the discourse or that it is brand-new. The most interesting and novel finding is that concept and referent activation interact in such a way that they lead to additional pragmatic inferences, which are computed at the sentence and not at the noun level. This, we believe, is yet another example of the dynamicity of referent management in discourse.

Additional File

The additional file for this article can be found as follows:

- **Appendices A & B.** Materials used in Experiments 1 and 2. DOI: https://doi. org/10.5334/gjgl.457.s1

Competing Interests

The authors have no competing interests to declare.

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