How to trivialize uniqueness[1]

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Abstract A new unified account for anaphoric and non-anaphoric (attributively used) definite descriptions is proposed that avoids making use of lexical ambiguities and the notion of *minimal situations*.

Keywords: definite article, uniqueness, anaphoricity, (minimal) situation.

1. Introduction

Definite descriptions can be used with and without antecedents, i.e., anaphorically and non-anaphorically ('self-standing'). If they are used non-anaphorically, *uniqueness effects* arise,[2] which are generally absent when they are used anaphorically. That is, a self-standing definite description is often understood as conveying that one and only one individual bears the property its restrictor expresses.[3] Thus, (1a) suggests that there is exactly one (relevant) actor. Circumstances of evaluation where this is not the case are thus rejected. This uniqueness effect—i.e., the rejection of certain circumstances—does not arise when definite descriptions are used anaphorically. The definite description in (1b) does not seem to claim that there exists only one (relevant) actor but just relates back to the subject of the first sentence:

(1) a. The actor went broke.
    b. Johnny Depp is in trouble. The actor went broke.

Either the presence of a uniqueness effect in one case or its absence in the other stands in need for some explanation. The only other option is to argue in favor of a lexical ambiguity, i.e., to deny that the definite articles in (1a) and (1b) are the same element. The latter has been done quite convincingly for languages like German and Swiss German by Florian Schwarz (in Schwarz, 2009, 2012), while attempts to reconcile the conflicting observations by means of making use of *minimal situations* have been undertaken in *situation theory* (especially Elbourne, 2005, 2013; Kratzer, 2007). The gist of the latter sort of proposal is to amend the anaphoric use of definite descriptions to the self-standing use by describing anaphoricity as being mediated by very small, *minimal*, situations—in the case at hand, a situation just consisting of Johnny Depp—so that there is, in fact, only one actor.

This article argues that the definite descriptions in (1a) and (1b) are indeed the same lexical element, and that it is possible to make that claim without adopting the situation-based approach towards anaphoricity just sketched. Instead, a version of Irene Heim's *File Change Semantics*

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[2]Excluding predicatively used definites as in, e.g., *Magnus Carlsen is the greatest chess player of all time*.

[3]There are some exceptions that can be explained in terms of *relevance*; i.e., a definite description can be understood as stating the uniqueness of a *relevant* witness of a property. This was already observed by Russell as can be witnessed by the following passage (emphasis in the original):

> Now *the*, when it is strictly used, involves uniqueness; we do, it is true, speak of "*the* son-of So-and-so" even when So-and-so has several sons, but it would be more correct to say "*a* son of So-and-so." Thus for our purposes we take *the* as involving uniqueness. (Russell, 1905: 481)

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(FCS) is proposed in which (i) her entailment requirement is done away with, but (ii) a novel formulation of the uniqueness condition is given.

This paper is organized as follows: Section 2 briefly reviews the notion of uniqueness with respect to situations that originated in early versions of situation theory that will later be adopted in order to account for uniqueness effects of self-standing definite descriptions. Section 3 then introduces a highly stylized version of FCS together with Heim's *Extended Novelty-Familiarity-Condition* and discusses some shortcomings of the latter, especially the entailment requirement that gives rise to *Heim's Problem*. Section 4 then introduces the adapted version of FCS that makes use of crucial features of both kinds of accounts, and shows how the novel formulation of the uniqueness condition is trivialized in the anaphoric use of definite descriptions and thus behaves exactly as needed. Section 5 sketches the prospects of the account.

2. Uniqueness with respect to situations

At least since the work done in *situation theory* (Elbourne, 2013; Kratzer, 2007; Schwarz, 2009, a.o.), non-anaphoric uses of definite descriptions are commonly accounted for by relativizing their descriptive content to situations. This leads to the notion of *uniqueness with respect to a situation*: If a definite description of the form *the* + *NP* is evaluated against a situation *s*, there needs to exist exactly one individual in *s* that bears the property expressed by *NP* in order for the use of the definite description to be felicitous. So, for example, the situation theoretical paraphrase of (1a) thus is (2):

(2) There exists exactly one actor *x* in *s* and *x* went broke in *s*.

This kind of approach fares much better than a standard relativization of descriptive content to possible worlds could because situations can vary in 'size' (i.e., spatiotemporal extension) and therefore be rather small.[4] There is no need to claim that (2) can only be true if there exists a single actor in a complete world, which would raise the bar for using a definite description way too high.[5]

But if a definite description is used anaphorically, such a paraphrase is not appropriate anymore. The intuitive interpretation can be phrased as in the simple (3), using the antecedent's referent instead of the quantifying *there exists exactly one actor x in s* to paraphrase the contribution of the definite description in (1b).

(3) Johnny Depp went broke in *s*.

Elbourne (2005) tries to adapt the mechanism underlying the paraphrase in (2) to the use in (1b) by appealing to so called *minimal situations*. The idea, in a nutshell, is that situations are only so small as they need to be in order to make sentences true. Thus, to make the first sentence of (1b) true, only those situations are considered that contain nothing but the very individual

[4]It has been claimed that worlds can be rather small as well, see Cresswell (1988) for a case in point. If one endorses such a view, nothing is gained by taking situations rather than worlds to be the prime parameter of evaluation.

[5]But even if situations are allowed to vary in size, the run-of-the-mill situation that makes sentences uttered in a conversation true is not so small that it just contains one single individual. Thus, (1a) usually is not readily accepted if it does not refer to the context of utterance.

contributed by the proper name—i.e., Johnny Depp[6]—and the property of being in trouble. The second sentence then is evaluated against those situations that make the first sentence true, hence, the definite's descriptive content can only be checked against situations hosting nobody but Johnny Depp, the actor.[7] Thus, the paraphrase in (2) indeed yields the desired interpretation, since it turns out to be equivalent to the paraphrase in (3) (wrt. the relevant situations).

But, as is pointed out most notably in Zweig (2006), the notion of minimal situations is haunted by deep problems, which is why it is not utilized to account for anaphoric uses of definite descriptions in all varieties of situation theory. For example, Schwarz (2009) uses situations in a more theory-neutral way[8] and argues for a division of labor between a situation based theory of domain restriction (and hence self-standing uses of definite descriptions) and a dynamic (but not situation based) account of anaphoricity. To be concrete, he assumes the anaphoric use to be handled via coindexation of an additional anaphoric element in the definite description and its antecedent. The paraphrase of (1b) roughly is (4) (where x_1 is coindexed with *Johnny Depp* in the first sentence), which is equivalent to (3).

(4) There exists exactly one/an actor x in s that is identical to x_1 and x went broke in s.

Note—as Schwarz already points out—that this paraphrase is compatible with the presence of a Russellian uniqueness condition (indicated by *there exists exactly one* as in (2)), since the definite's descriptive content is restricted to actors that are identical to whatever x_1's interpretation is. But the price of this is that the definite article in (1a) needs to be different from the one in (1b), since there is no way of getting rid of this anaphoric component when it comes to self-standing uses. The first still is interpreted in the sense indicated by (2), while the second really comes down to the paraphrase in (3) (via (4)). Thus, there is one definite article that cannot be used anaphorically, and this version comes with a uniqueness condition, and there is another version that can only be used anaphorically that may or may not contain such a condition, which would be trivialized by the contribution of the anaphoric element.

Summing up, there are two attempts to reconcile the uniqueness implication of self-standing uses of definite descriptions with their anaphoric uses: the first, endorsed most notably by Elbourne, is to restrict the evaluation to minimal situations, so that the anaphorically used definite article can be the same as the self standing one, since the uniqueness condition is trivially satisfied due to the minimality of the situations in play. The second, defended by Schwarz, consists in an ambiguity thesis. Definite articles that are used anaphorically are more complex in that they feature a hidden anaphoric element that helps trivializing the uniqueness condition by revoking the property that has to hold of exactly one individual into an identity claim.

[6]The individual must be *thin* in the sense of Kratzer (1989), i.e., stripped of all properties, to avoid unwelcome consequences.

[7]To be precise, the property of being an actor needs to be added to the situations first, thus *extending* them without adding further individuals. This means that there could be candidate situations that make the first sentence true that do not support this second addition; e.g., situations in which Johnny Depp is no actor. These situations thus are eliminated, the definite's descriptive content is *accommodated*.

[8]Schwarz cannot fully avoid using minimal situations due to the way in which he handles quantification. But this does not affect the point made here.

3. File Change Semantics

In Heim's File Change Semantics (FCS), sentences are evaluated against *files*, i.e., technically speaking, sets of assignment functions from individual variables to individuals (the so called *satisfaction set*) together with a *domain*. The idea is, roughly speaking, that potential antecedents are stored under a variable name in the domain, which is valued by the assignments in the satisfaction set. The satisfaction set thus embodies the information that is associated with these (potential) antecedents. Its shape is regulated by the interpretation process that restricts the range of values according to the lexical material the variables are introduced with. For example, if a sentence like the following is considered, an indefinite description like "a young researcher" opens up such a new 'address'—say x_1—under which every possible individual is stored that is compatible with the information given.

(5) A young researcher blew up his lab after he tried to reproduce the results of an experiment conducted earlier this year by a team that was assembled by his father.

The interpretation procedure has to run through the sentence from left to right. One can think of this as ongoing restriction: first, every individual could be the witness of the indefinite article "a", which needs to be interpreted first. It just adds a fresh variable to the domain but does not reduce the number of assignments in the satisfaction set since it is compatible with all kinds of continuations. After interpreting its restrictor "young researcher", this range of values is reduced considerably, by eliminating every assignment that does not value the variable accordingly. Then the information that the value of x_1 has to have had a lab (which he then blew up) is added which restricts the range of values even further (and introduces further variables into the domain to store the former lab etc.); and so forth as long as new information is supplied. Generally, the domain of the file can be thought to be empty at the start of a discourse, but then gets filled with more and more variables as soon as sentences like (5) are interpreted. Conversely, the satisfaction set initially consists of the set of all possible assignment functions and starts to shrink while the domain gets filled.[9]

Heim (1982) famously attempts to cover anaphoric and non-anaphoric uses of definite descriptions with her *Extended Novelty-Familiarity-Condition*. This is basically achieved by distinguishing two aspects of *familiarity* (cf. Roberts, 2003, 2004): one that also pertains to personal pronouns, namely the availability of a suitable antecedent, and an *entailment requirement* to be addressed separately. The first sense of familiarity can be modeled by the domain of the file alone. If one assumes in addition to the linear (left to right) interpretation procedure that there is no other way for a variable to enter the domain apart from being introduced into it by (in)definite descriptions (and proper names), the variables in the domain correspond to all potential (and accessible[10]) antecedent expressions in the discourse.[11] Indefinites have to use a fresh vari-

[9]The satisfaction set does not need to shrink because one can introduce variables into the domain that are accompanied by trivialities, e.g., *something either is or is not concrete.* This adds whatever variable is used to translate *something* to the domain without excluding any of its possible values.

[10]There are environments that block the projection of discourse referents, e.g., the complements of negation. Thus, not every suitable expression introduces variables that can be taken up by subsequent anaphoric expressions.

[11]This assumption ultimately needs to be rejected if one tries to account for deictical uses of personal pronouns and definite descriptions because in this case, there need to be variables in the domain whose values are, e.g., demonstrated objects in the context of utterance. Thus, there needs to be a different way to enter the domain apart from being introduced by one of the expressions mentioned. This can be adapted in the present framework as

able, i.e., a variable that is not part of the domain of the file they are interpreted against. This is the *novelty*-requirement, which makes it impossible to use indefinite descriptions anaphorically and thus prevents them from erasing information already established. Pronouns, on the other hand, need an antecedent. This means that they have to be translated by a variable that is already part of the domain.[12] This is the first sense of *familiarity*. But since definite descriptions need not to be used anaphorically, Heim proposes a second sense of familiarity, namely the requirement that their descriptive content needs to be entailed by the common ground. This basically means that the values of the variable introduced by self-standing definite descriptions need to be somewhat predetermined (or 'foreshadowed') by the satisfaction set of the file. Understood this way, definite descriptions do not introduce something new into the discourse, but just make something explicit that has been assumed (or presupposed) already. To spell this out, Heim relativizes the satisfaction set of files to possible worlds and defines entailment as close as possible to classical possible worlds semantics, namely as a subset relation between two satisfaction sets at the same world. A file F therefore entails a formula φ iff it holds for every world w that the satisfaction set $Sat_w(F)$ of F is a subset of the satisfaction set at the very same world that is the result of interpreting φ against F; i.e., in her notation (Heim, 1982: 236)

(6) F entails φ iff $Sat_w(F) \subseteq Sat_w(F + \varphi)$, for every world w.

In other words: a file F entails the truth of a formula φ iff it is possible to add φ to F's (world dependent) satisfaction set without shrinking it, i.e., loosing a single assignment function.[13]

There are two problems with this account. The first is that it does not seem to be necessary that the content of a self-standing definite description is already entailed by the file; i.e., not every self-standing usage of a definite description merely makes something explicit that was already part of the common ground, as can be seen by the existence of so-called *informative presuppositions*. That is, it is possible to use presuppositional devices consciously in conversations where the common ground clearly does not entail the presupposed material in question. Secondly, in certain environments, the entailment requirement enforces demands on the common ground that are too strong— a puzzle which was coined *Heim's Problem* (cf. Heim, 1982, 1983; Aloni, 2001; Dekker, 2012). A case in point is the following sentence taken from Heim:

(7) A fat man pushes his bicycle.

Assuming—just for the sake of argument—that "his bicycle" abbreviates something like "the bicycle he owns", i.e., a definite description, (7) demands that every fat man in the domain of quantification owns a bicycle. To see this, one needs to go through the sentence from left to right. If the domain of the file is empty, "a fat man" introduces a new variable name—x_3 for later reference—and restricts the range of its values to fat men (by eliminating assignments from the satisfaction set that value x_3 differently). Then, the verb phrase together with the hidden definite description needs to be interpreted. The pronoun has to be coindexed with the

well; see the (brief) remarks in Section 5.

[12] Or have to be 'linked' to one, e.g., introduce a new variable that is claimed to be valued identically to some other variable that was in the domain before. This second way of relating pronouns to their antecedents is the way in which *Discourse Representation Theory* (DRT; Kamp, 1981; Kamp and Reyle, 1993) handles resolution.

[13] From this, entailment between formulas can be derived as follows: one first has to update an unaltered file with all premises, and then show that the resulting file entails the conclusion. If this is the case, then the premises entail the conclusion.

(contribution of) "a fat man" to derive the intended interpretation. Thus, the definite descriptions spells out as "the bicycle x_3 owns". Given the procedure outlined above, this again inserts a new variable into the domain—say, x_4—that is restricted to bicycles owned by fat men. Then the entailment requirement demands that this update does not loose a single assignment function that was present prior to the interpretation of the definite description. But exactly this happens if there exists a fat man in the domain of quantification who does not own a bicycle. If there is an assignment that assigns this man to x_3 then there cannot be an extension of it that assigns a bicycle he owns to x_4. Hence, this assignment is abandoned, which violates the entailment requirement. Thus, the definite description is predicted to be infelicitous, contrary to fact.

Leaving the entailment requirement aside, this machinery allows for anaphoric relationships even across clause boundaries and thereby captures anaphorically used definite descriptions. But, as it stands, it does not capture the uniqueness effects of self-standing uses, assuming the view of the previous section to be correct. The problem of Heim's (and similar) system(s) is that the situation variables needed to account for these effects in non-anaphoric uses are alien to the file. Thus, the dilemma in a nutshell seems to be that if definite descriptions are used anaphorically, they need to be evaluated against the file, but if they are used non-anaphorically, they need to be evaluated at some situation (variable) s. Thus, in order to not subscribe to an ambiguity thesis again, one needs to reconcile these two parameters of evaluation.

The final step to undertake in this section is the formulation of a version of FCS that is pretty close to the original one as just described, but comes with some simplifications. This version of FCS was mainly laid out in Dekker (1996). He shows that FCS can be understood as a version of Groenendijk and Stokhof's (1991) *Dynamic Predicate Logic* (DPL) with partial states and an extension relation in place of the relation of x-variants. That is, he incorporates the basic features of FCS into a language that syntactically looks like first order predicate logic. Since the syntax is pretty standard, its definition is omitted here. Dekker's first simplification consists in using sets of partial assignments instead of total assignments (as Heim does) to form satisfaction sets because, as soon as one assumes their domains to be homogeneous—covering the same variables—the domain of a file can be read off of these sets.[14] To establish some notation: g^X is an assignment function with the domain X, which is a (finite) set of variables. The superscript is omitted whenever not relevant. A set of variables X is the domain of a partial assignment function f iff it holds for all elements x of X that $f(x)$ is a proper individual while it holds for all y that are not in X that $f(y) = \#$. A file is a set of assignment functions G such that for any two elements of G it holds that their domains coincide. This guarantees that the file consists only of homogeneous assignment functions and their domain can be said to be G's domain as well. The second of Dekker's amendments consists in using an extension relation as the following, which is well known from DRT's interpretation mechanism as well:

(8) $\quad f^X \subseteq_V g^Y$ iff $Y = X \cup V$ & $\forall x \in X : g(x) = f(x)$

That is: an assignment function g (with domain Y) extends an assignment function f (with domain X) by the set of variables V iff g covers all variables f covers, does not differ from f's

[14] Partial assignment functions can be represented by total assignment functions defined over a domain enriched by a 'dedicated individual': if M is the domain of individuals, $M \cup \{\#\}$ is the domain "partial" assignment functions are defined over.

assignments on the 'old' domain X, and additionally also comes up with values for the variables in V (not in X). Note that V can be empty, in which case this relation boils down to identity. Note further that X and V are allowed to overlap, but that this does not mean that g can value some variable in $X \cap V$ differently from f. This extension relation just is not picky in the sense whether the variables in V need to be 'fresh' or not. A relation that only allows for extensions by 'new' variables can be obtained from (8) by demanding that X and V do not overlap:

(9) $\quad f^X \subset_V g^Y$ iff $X \cap V = \emptyset$ & $f^X \subseteq_V g^Y$

This stronger relation can be utilized to state Heim's *Extended Novelty-Familiarity-Condition* in terms of definedness conditions for formulas.[15] As said above, novelty and familiarity (in the first sense) can be stated with respect to the domain of a file alone if it is guaranteed that there is no way for a variable to enter a file's domain but by being introduced into it by a suitable expression. If this is the case, then it is enough for a variable to be new with respect to the domain for it to be used for the first time in a discourse.[16] Hence, making the stronger extension relation (9) part of the definedness-conditions of the existential quantifier (10d), which in turn is used to translate indefinite expressions,[17] does the intended job of modeling novelty: if the variable accompanying the existential quantifier—e.g., x_{23}—was already in use, the set of extensions of elements of G based on the strong relation—i.e., $\{h : \exists g \in G : g \subset_{\{x_{23}\}} h\}$—is empty and hence, the whole formula is undefined; as desired.[18]

The other clauses of (10) are as one expects from a dynamic system: atomic formulas are defined as soon as every term is defined; conjunctions are defined iff the successive application of their left and right conjuncts (in that order) is; and negated formulas are defined as soon as their positive counterparts are:

(10) *FCS: Definedness conditions*: An expression α is defined for a file G iff $[\![\alpha]\!]^d(G) \neq \emptyset$
- a. $[\![R\tau_1, \ldots, \tau_n]\!]^d(G) = \{g \in G : g(\tau_1) \neq \# \;\&\; \ldots \;\&\; g(\tau_n) \neq \#\}$
- b. $[\![\varphi \wedge \psi]\!]^d(G) = [\![\psi]\!]^d([\![\varphi]\!]^d(G))$
- c. $[\![\neg\varphi]\!]^d(G) = [\![\varphi]\!]^d(G)$
- d. $[\![(\exists x_i)[\varphi]]\!]^d(G) = [\![\varphi]\!]^d(\{h : \exists g \in G : g \subset_{\{x_i\}} h\})$

The truth conditions expressed by the formulas are stated very similarly (R' in (11a) is a constant that represents R's extension):

(11) *FCS: Truth conditions*: A sentence φ is true wrt. G iff φ is defined for G and $[\![\varphi]\!]^+(G) \neq \emptyset$

[15] Both extension relations are already found in the excellent van den Berg (1996), where several notions of partiality are identified and discussed. The notion of definedness that is relevant here is the one that solely concerns the "bookkeeping device". That is, in contradistinction to other modes of partiality like presuppositions, there is no need to fully go three-valued, since there should not be a way back from undefinedness to truth or falsity. Undefinedenss only arises from violations of the *Extended Novelty-Familiarity-Condition*, which should not be repairable. Even though van den Berg has both (8) and (9), he does not put them to exactly the same use as it is done here, and neither does Dekker.

[16] Except for occurrences under negation. But since negation blocks the projection of discourse referents, these occurrences do not matter.

[17] This is, strictly speaking, not the way Heim sets up FCS in Heim (1982), but the way in which Dekker (1996) modifies DPL to incorporate her basic assumptions.

[18] There are good reasons to doubt that this is the whole story concerning novelty. (See Muskens, 1996 and especially Krifka, 2001.) Since capturing novelty is not at the center of interest, this discussion is not entered here.

a. $[\![R\tau_1,\ldots,\tau_n]\!]^+(G) = \{g \in G : \langle g(\tau_1),\ldots,g(\tau_n)\rangle \in R'\}$
b. $[\![\varphi \wedge \psi]\!]^+(G) = [\![\psi]\!]^+([\![\varphi]\!]^+(G))$
c. $[\![\neg\varphi]\!]^+(G) = \{g \in [\![\neg\varphi]\!]^d(G) : [\![\varphi]\!]^+(\{g\}) = \emptyset\}$
d. $[\![(\exists x_i)[\varphi]]\!]^+(G) = [\![\varphi]\!]^+(\{h : \exists g \in G : g \subset_{\{x_i\}} h\})$

As the inclined reader is invited to verify, the semantics in (11) together with the definedness-conditions in (10) allows one to account for novelty and anaphoricity in little discourses featuring indefinite descriptions (translated as existentially quantified formulas) and pronouns (translated as plain variables). Note further that the clause for conjunctions enforces left-to-right interpretation while the clause for negation blocks the projection of discourse referents introduced in its scope.

4. The combination of the two

This section shows how the two kinds of approaches outlined in the previous sections can be combined. What needs to be done is the following: (i) situation variables need to make their appearance in formulas as well as in the domains of files in order to have the notion of uniqueness with respect to a situation available even in a dynamic setting; (ii) a specific kind of *update* has to be performed by the interpretation of definite descriptions in order to capture their use as self-standing or anaphoric, respectively; and (iii) the *uniqueness condition* has to apply to its input and its result. Both the update and the uniqueness condition are part of the lexical entry for definite articles, which will be given with the help of a dedicated quantifier prefix "❑".

4.1. iFCS

For the purpose of this paper, it is enough to endow the (implicit) syntax of FCS with a *single* situation variable. Neither Kaplanian two-dimensionality nor attitude ascriptions are tackled here, since the implementation of the means to deal with formulas that depend on more than one situation is rather involved. That means that every sentence will depend on one situational argument in total, which will feature in the translation of predicative material, i.e., (sortal) nouns and verb phrases. It is therefore tacitly assumed that the implicit syntax of FCS above is endowed with a single situation variable—s for further reference.[19] This syntactic change has consequences for files. They cannot start with empty domains anymore because the omnipresent situation variable would not receive a value and thus, no formula could possibly be defined. Hence, the file needs to cover the one situational component from the get-go. In this sense, FCS is intensionalized. In its initial state it covers the situation variable only—collecting all of its possible valuations. Thus, the initial file represents Logical Space (LS), the set of all possible situations. Since further individual variables can be introduced into the domain, assignments generally represent *indices*, i.e., situations paired with a finite list of individuals; and files represent sets of such indices, i.e., something very similar to standard propositions. This shift in granularity helps in explaining the oscillation of the uniqueness effect.

[19]The adaptation of the first order syntax is straightforward. One has to avoid any possible confusion of individual variables—x_i—with the situation variable, though. That is, there should not be a way to quantify over s in the present framework, meaning that constructions like $(\exists s)[\varphi]$ should be blocked syntactically. True intensionality (understood as quantification over the situational compoment) must be implemented differently, in order to leave the "bookkeeping device" untroubled.

With the syntax and the ontology in place, it is now time to give the definitive form of the definedness and truth conditions of intensionalized FCS—iFCS for short:

(12) *iFCS: Definedness conditions*: An expression α is defined for a file G iff $[\![\alpha]\!]^d(G) \neq \emptyset$
- a. $[\![Rs\tau_1,\ldots,\tau_n]\!]^d(G) = \{g \in G : g(s) \neq \# \;\&\; g(\tau_1) \neq \# \;\&\; \ldots \;\&\; g(\tau_n) \neq \#\}$
- b. $[\![\varphi \wedge \psi]\!]^d(G) = [\![\psi]\!]^d([\![\varphi]\!]^d(G))$
- c. $[\![\neg\varphi]\!]^d(G) = [\![\varphi]\!]^d(G)$
- d. $[\![(\exists x_i)[\varphi]]\!]^d(G) = [\![\varphi]\!]^d\left(\{h : \exists g \in G : g \subset_{\{x_i\}} h\}\right)$

(13) *iFCS: Truth conditions*: A sentence φ is true wrt. G iff φ is defined for G and $[\![\varphi]\!]^+(G) \neq \emptyset$
- a. $[\![Rs\tau_1,\ldots,\tau_n]\!]^+(G) = \{g \in G : \langle g(s), g(\tau_1),\ldots,g(\tau_n)\rangle \in R'\}$
- b. $[\![\varphi \wedge \psi]\!]^+(G) = [\![\psi]\!]^+([\![\varphi]\!]^+(G))$
- c. $[\![\neg\varphi]\!]^+(G) = \{g \in [\![\neg\varphi]\!]^d(G) : [\![\varphi]\!]^+(\{g\}) = \emptyset\}$
- d. $[\![(\exists x_i)[\varphi]]\!]^+(G) = [\![\varphi]\!]^+\left(\{h : \exists g \in G : g \subset_{\{x_i\}} h\}\right)$

As can be seen, the switch from FCS to iFCS is only reflected in the clause for atomic formulas, where the single situation variable s makes its appearance. In contrast to the extensional fragment before, R' now has to stand for the *intension* of R. Apart from that, everything stays the same.

4.2. Definite descriptions in iFCS

A definite description that is evaluated against a file A performs a special kind of update that leads to a (possibly different) file B. In this update, two cases are possible: If the individual variable the definite description comes with, x_i, is new with respect to A's domain (i.e., has not occurred before so that the definite description is self-standing), it is introduced into it and its values are restricted to those that fulfill the description's restrictor with respect to the values stored in the assignment. If x_i was used before, the file A is freed from those assignments that store individuals under x_i that do not fulfill the description's restrictor. Crucially, both cases can be captured simultaneously with the help of the weaker of the two extension relations (8), which is compatible with x_i being new or old. Thus, the first step in the interpretation and the definedness condition are rather similar to those of indefinite descriptions:

(12) e. $[\![(\square x_i)[\varphi]]\!]^d(G) = [\![\varphi]\!]^d\left(\{h : \exists g \in G : g \subseteq_{\{x_i\}} h\}\right)$

But the work is not done yet. In a second step, both the input file A and the output file B serve as arguments for the *uniqueness condition* that demands that a special *relation* holds between the files:

(14) For any sets of assignments A, B, and individual variables x_i: $\textsc{Unique}_{x_i}(A)(B)$
$= \{h \in B : \exists g \in A\, \exists V\, g \subseteq_V h \;\&\; (\forall h' \in B)[g \subseteq_V h' \rightarrow h(x_i) = h'(x_i)]\}$

Informally, this condition checks whether those assignments h in B that are extensions of a single assignment g in A ("$\exists V\, g \subseteq_V h$"[20]) assign the same individual to x_i. If all of them do, they are kept; if they do not, they are eliminated. Even more compressed, the uniqueness

[20] V is not restricted to $\{x_i\}$ in order to allow for the introduction of further variables in the scope of $\square$. Note further that it suffices to pay attention to the difference of the domain of the initial file X and the second one Y—i.e., $V = Y \backslash X$. If a V exists that makes the output non-empty, it is this one.

condition demands there to be only one value of the definite's variable per input assignment in the output. If it is not possible to introduce more than one value for x_i on the basis of what is found in an element of A, uniqueness holds with respect to this element and hence also with respect to the situation variable's value stored in it. If the variable occurred before, B is a subset of A, thus, every element of B extends *exactly* one element of A, namely itself. Hence, the uniqueness condition is trivialized in the anaphoric case. Thus, non-anaphorically (attributively) used definite descriptions and anaphorically used ones can be represented by one and the same lexical element, whose truth conditions are thus the following:[21]

(13) e. $[\![(\square x_i)[\varphi]]\!]^+(G) = \textsc{Unique}_{x_i}(G)\left([\![\varphi]\!]^+(\{h : \exists g \in G : g \subseteq_{\{x_i\}} h\})\right)$

4.3. Examples

Armed with the definitions above, it is time to calculate some examples. The first two will feature self-standing uses of definite descriptions, one where the uniqueness condition is satisfied for all situations in play and one where it is not. Then anaphoric uses are discussed, showing how the very same uniqueness condition is necessarily trivialized in case there is an antecedent in the file's domain.

4.3.1. Self-standing uses

For illustrative purposes, imagine four situations s_1–s_4 such that there exists only one man in each of them, namely a in s_1 and s_2, b in s_3 and c in s_4. Thus, when a definite description like *the man* (parsed as (15)) is interpreted against any of those situations, the uniqueness condition should be satisfied because there exists only one man per situation.

(15) $(\square x_1)[Msx_1]$

To show that this prediction is borne out, consider what the described update procedure does to the initial state of a file G (cf. (16a)), just consisting of all possible values for the one situation variable s: since x_1 is new with respect to G, it is simply added to the domain and it is assigned every possible individual as value. Then, the descriptive part of the definite description eliminates all non-men from the so created intermediate file, yielding the file H in (16b)—(16b) is thus the result of calculating $[\![Msx_1]\!]^+\left(\{h : \exists g \in G : g \subseteq_{\{x_1\}} h\}\right)$. Because of the situations being as described, this procedure cannot produce any other output. Then, the uniqueness condition in (14) comes into play. It checks whether it holds for any input assignment in G (its first argument) that gets extended in H (its second argument) that there is no further extension in H that hosts a different individual in the x_1-slot. There are other assignments, but they extend different input assignment and thus do not interfere. Hence, the uniqueness condition yields H as a final result (given that nothing of interest happens in the omitted part).

[21] The uniqueness condition is not part of the definedness conditions for definite description due to what is said in fn. 15: the notion of partiality that is modeled here is not that of presuppositions (or presupposition failures), but of the "bookkeeping device". If one wants to talk about presuppositions, further definedness conditions (on top of (12)) have to be introduced. The interested reader is once again referred to van den Berg (1996).

(16) a.

G	s	x_1	…
g_1	s_1	#	…
g_2	s_2	#	…
g_3	s_3	#	…
g_4	s_4	#	…
…	…	…	…

b.

H	s	x_1	…
h_1	s_1	a	…
h_2	s_2	a	…
h_3	s_3	b	…
h_4	s_4	c	…
…	…	…	…

This is different in case there is another situation, s_5 in which more than one man (namely c and d) exists. This situation then also is part of the initial state G' (cf. (17a)). This time, the assignment assigning s_5 to s gets extended by two assignment functions in H'—i.e., $[\![Msx_1]\!]^+\big(\{h : \exists g \in G' : g \subseteq_{\{x_1\}} h\}\big)$—, namely $h'_{5.1}$ and $h'_{5.2}$, because the definite's restrictor fails to eliminate either of those two (possible) values of x_1. In this configuration, the uniqueness condition (14) eliminates both assignments from H' (which it takes as second argument next to G'), yielding H'', because it only collects those assignments from H' that behave as desired. Thus, every descendant from the initial assignment g_5 that assigns s_5 to s is trashed in the process. The non uniqueness-supporting situations are thus removed from the file.[22]

(17) a.

G'	s	x_1	…
g'_1	s_1	#	…
g'_2	s_2	#	…
g'_3	s_3	#	…
g'_4	s_4	#	…
g'_5	s_5	#	…
…	…	…	…

b.

H'	s	x_1	…
h'_1	s_1	a	…
h'_2	s_2	a	…
h'_3	s_3	b	…
h'_4	s_4	c	…
$h'_{5.1}$	s_5	c	…
$h'_{5.2}$	s_5	d	…
…	…	…	…

c.

H''	s	x_1	…
h'_1	s_1	a	…
h'_2	s_2	a	…
h'_3	s_3	b	…
h'_4	s_4	c	…
…	…	…	…

4.3.2. Anaphoric uses

A definite description is used anaphorically if the variable it comes with was used in interpreting some expression uttered the discourse before. Then, the variable is in the domain of the file the definite description is interpreted against. The introducing expression might have been a different definite description, namely one of those discussed in the preceding subsection, or any other expression that is endowed with the capability to introduce discourse referents, e.g., indefinite descriptions, proper names, and the like. In this case, the anaphorically used definite description does not introduce a fresh variable into the domain, but simply elaborates on the values that are stored in the file. Thus, there are just two cases to consider: either (i), all the values stored under the variable name in the input file fulfill the descriptive content expressed by the restrictor, then the update does not alter the file at all, or (ii) some of the values (or even all) do not pass this test, then the respective assignments are eliminated; the definite's descriptive content is accommodated again. Thus, the outcome of the first interpretation step either is an unaltered input file (i) or a subset thereof (ii). The uniqueness condition (14) thus is either fed, e.g., G'' (cf. (18a)) twice, or G'' as first and H''' (cf. (18b)) as second argument:

[22] This corresponds to the *accommodation*-step in Heim's system.

(18) a.

G''	s	x_1	…
g''_1	s_1	a	…
g''_2	s_2	b	…
g''_3	s_3	a	…
g''_4	s_4	a	…
g''_5	s_4	b	…
…	…	…	…

b.

H'''	s	x_1	…
g''_3	s_3	a	…
g''_4	s_4	a	…
g''_5	s_4	b	…
…	…	…	…

In both cases, the uniqueness condition returns its second argument without any changes for trivial reasons. In the first case because every assignment in G'' extends itself and only itself (focusing attention on $V = \emptyset$), and thus, there is no different second assignment in G'' per input assignment in G'' that could differ in the value for x_1; in the second case because the remaining assignments in H''' also extend themselves (in G''), while the other assignments in G'' do not matter at all. This is because the uniqueness condition (14) reads "*if* there is an assignment in the second argument (H'') that extends an assignment in the input (G''), *then* there is no further assignment that does the same while differing in the value for x_1." Thus, since no extension of the domain of the assignments takes place, the uniqueness condition holds trivially, without implying uniqueness of the value of x_1 (with respect to the property expressed by the restrictor) in the situation that is the value of s, as is witnessed by g''_4 and g''_5 in G'' and H'''.

4.3.3. More involved cases

The two basic cases just discussed are not affected by more structure in the initial files. That is, it does not change anything substantial if the variable introduced by the definite description is not the first individual variable in the domain of the file. If a file like J is considered that might be thought of as arising from interpreting a (sequence of) sentence(s) containing an indefinite description that made use of x_2, a definite description like (15) still can introduce its x_1 together with all possible values and reduce them to men in the situations stored in the assignments under s. The result of this cannot be a file like J' that would wrongly pass the uniqueness condition (14) unaltered because J' does not contain all assignments compatible with the facts. If the situation s_1 indeed hosts three men d, e, and f, then it is not enough to extend the first assignment in J by only one assignment as it is done in J'. Instead, j_1 in J alone has to have three extensions, namely $j''_{1.1} - j''_{1.3}$ as in J''. The same then holds for j_2 and j_3 in J. These assignments too have to have three extensions, as depicted in J'', covering all the men in s_1.

(19) a.

J	s	x_2	x_1	…
j_1	s_1	a	#	…
j_2	s_1	b	#	…
j_3	s_1	c	#	…
j_4	s_2	a	#	…
j_5	s_2	c	#	…

J'	s	x_2	x_1	…
j'_1	s_1	a	d	…
j'_2	s_1	b	e	…
j'_3	s_1	c	f	…
j'_4	s_2	a	d	…
j'_5	s_2	c	d	…
…	…	…	…	…

b.

J''	s	x_2	x_1	…
$j''_{1.1}$	s_1	a	d	…
$j''_{1.2}$	s_1	a	e	…
$j''_{1.3}$	s_1	a	f	…
$j''_{2.1}$	s_1	b	d	…
$j''_{2.2}$	s_1	b	e	…
$j''_{2.3}$	s_1	b	f	…
$j''_{3.1}$	s_1	c	d	…
$j''_{3.2}$	s_1	c	e	…
$j''_{3.3}$	s_1	c	f	…
j'_4	s_2	a	d	…
j'_5	s_2	c	d	…
…	…	…	…	…

If J and J'' are handed over to the uniqueness condition (14) as first and second argument, respectively, all assignments hosting s_1 as the value of s are eliminated. There simply is no single man with respect to s_1, thus, this is the desired outcome.

The presence of additional individual variables in the file's domain allows the definite description to introduce its variable based on more parameters than just the situation variable s. If, e.g., (20b) is taken to be the translation of the definite description together with the restrictive relative clause in (20a), whereas x_1 is the translation of the pronoun, then the additional discourse referent matters.

(20) a. A girl ate the chewing gum she bought.
b. $(\square x_2)[Csx_2 \wedge Bsx_2x_1]$

(21) a.

J	s	x_1	x_2	…
j_1	s_1	a	#	…
j_2	s_1	b	#	…
j_3	s_2	a	#	…
j_4	s_2	b	#	…
…	…	…	…	…

b.

J'	s	x_1	x_2	…
j'_1	s_1	a	c_1	…
j'_2	s_1	b	c_2	…
$j'_{3.1}$	s_2	a	c_1	…
$j'_{3.2}$	s_2	a	c_2	…
j'_4	s_2	b	c_3	…
…	…	…	…	…

In contrast to a sentence like *a girl ate the chewing gum* that—assuming that the definite description is used non-anaphorically—would force the uniqueness condition (14) to eliminate all assignments assigning a situation with more than one chewing gum to s—in the case at hand, all assignments featuring s_1 or s_2—(20a) allows for a more fine-grained elimination. This is due to the relative clause, i.e., the relativization of chewing gums to those bought by the value of x_1. Thus, a definite description like (20b) interpreted against a file like (21a) yields (21b). The uniqueness condition then eliminates those assignments that assign more than one value to x_2 per input assignment in J, namely $j'_{3.1}$ and $j'_{3.2}$. Thus, it excludes girls that bought more than one chewing gum. The final outcome is (21c):

(21) c.

J'	s	x_1	x_2	…
j'_1	s_1	a	c_1	…
j'_2	s_1	b	c_2	…
j'_4	s_2	b	c_3	…
…	…	…	…	…

As can be seen, even though there is a girl in s_2 that bought more than one chewing gum—namely a—, s_2 as a possible value of s is not eliminated from the file altogether. Only those assignments featuring a and s_2 (as values of x_1 and s) are cut in the process; j'_4 remains to be a candidate because b only bought one chewing gum. That assignments featuring s_2 pass the test the uniqueness condition poses means that this account does not suffer from *Heim's Problem*.

Cases of bridging can be understood along the same lines as this last example as well. If the second sentence of (22) is parsed as indicated in (22a), i.e., with a hidden anaphoric element in *steering wheel*, then the definite description emerging from this parse is as in (22b). Thus, once again, the value of x_3, the variable newly introduced by the definite article, depends on more than just the situational parameter, namely the hidden anaphoric x_2, relating back to the car introduced in the first sentence. The steering wheel introduced on this basis then is unique with respect to a car in the situation without needing to be unique with respect to the situation simpliciter.

(22) Peter has a new car. The steering wheel is yellow.
  a. Peter^{x_1} has a^{x_2} new car. The^{x_3} steering wheel of it$_{x_2}$ is yellow.
  b. $\ldots (\square x_3)[Ssx_2x_1] \wedge Ysx_3$

Furthermore, for completeness' sake, the lexical entries introduced can also deal with complex restrictors as in (23)

(23) a. The^{x_1} man with a^{x_2} cat … $(\square x_1)[Msx_1 \wedge (\exists x_2)[Csx_2] \wedge Wsx_2x_1]$
  b. The^{x_1} man with the^{x_2} cat … $(\square x_1)[Msx_1 \wedge (\square x_2)[Csx_2] \wedge Wsx_2x_1]$

Neither the presence of the second definite description in (23b) nor the indefinite article in (23a) change anything substantial. This is due to the selective nature of the uniqueness condition (14). Suppose again that the whole definite description in (23a) is interpreted against a rather sparse file like K and that the update that provides the second argument for the uniqueness condition yields K':

(24)

K	s	x_1	…
k_1	s_1	#	…
k_2	s_2	#	…
k_3	s_3	#	…
…	…	…	…

K'	s	x_1	x_2	…
$k'_{1.1}$	s_1	m_1	c_1	…
$k'_{1.2}$	s_1	m_2	c_2	…
k'_2	s_2	m_3	c_3	…
$k'_{3.1}$	s_3	m_1	c_1	…
$k'_{3.2}$	s_3	m_1	c_2	…
…	…	…	…	…

K''	s	x_1	x_2	…
k'_2	s_2	m_3	c_3	…
$k'_{3.1}$	s_3	m_1	c_1	…
$k'_{3.2}$	s_3	m_1	c_2	…
…	…	…	…	…

If the uniqueness condition applies to K and K', it rightly eliminates all extensions of k_1, namely $k'_{1.1}$ and $k'_{1.2}$, simply because the update procedure had no choice but to introduce more than one value for x_1. But, as depicted in K'', extensions of k_3 survive this procedure because there is only one man in the column for x_1. The presence of more that one cat in the next column—or, more generally, branching paths—does not interfere with the workings of the uniqueness

condition (14) because it is only interested in the number of values x_1 is assigned. That is why it can be called *selective*.

K'' also depicts an intermediate stage in the interpretation of the example with two nested definite descriptions (23b). It is not the argument of the uniqueness condition of the outermost definite article, though, but arises before the uniqueness condition of the inner definite is calculated. This step eliminates extensions of k_3 because *cat* is not relativized to anything apart from the situation variable. Thus, if there is more than one cat in a situation with only one man, the respective assignments get eliminated. The extensions of k_1 are not affected by this step, but get eliminated by the outer definite's uniqueness condition, as before. Hence, the only element of K'' that makes it is k'_2.[23]

Note finally that the present system is able to deal with classical counterexamples to situation-based accounts of uniqueness effects, namely (variants of) *sage-plant examples* and *bishop sentences* (cf. Heim, 1990):

(25) a. If someone buys a sage plant, she buys eight other along with the sage plant.
b. If a bishops meets a bishop, the bishops blesses the bishop.

The definite descriptions in (25) would all violate uniqueness with respect to the situation if they were used non-anaphorically. This holds true even in situation-theoretical systems where the 'size' of the situation is strictly regulated by the interpretation of the preceding material. That is, every 'minimal' situation that makes the antecedent of the conditional in (25b) true needs to contain at least two bishops so that there is no way in which the definite description can be felicitous. Roughly the same holds for (25a) as well, where it would be wrong to paraphrase the contribution of the definite description as *the sage plant she bought*, if this paraphrase is meant to feature a self-standing definite description. Since there is no situational part where the person in question buys a single sage plant—at least, its not immediately obvious that buying nine sage plants can always be analyzed into nine individual buying events, featuring only a single sage plant each—the situation-theoretical approach to anaphoricity runs into a problem. Admittedly, this kind of parse does not make it in the present system as well (it renders the sentence self-defeating), but there is a simple alternative: instead of introducing a new variable, the definite description can reuse the one introduced by the indefinite "a sage plant". This carries over to (25b) as well: assuming that both indefinite descriptions "a bishop" each introduce their own variable (which they do according to the lexical rules in (12) and (13)), the following definite descriptions can each reuse one of them. Furthermore, using "a sage plant" in (25a) is compatible with buying more than one; and anaphorically relating back to the indefinite with a definite description does not change that.

That the sentences feel unnatural to some degree might be due to two factors. Both readings could be expressed by using personal pronouns instead of full definite descriptions and hence, by using 'lighter' lexical material. Furthermore, the symmetry of the configuration in (25b) may contribute to the oddness in the following sense: it cannot be determined whether the first definite anaphorically relates back to the first indefinite or to the second; and likewise for the

[23]Thus, the system at hand does not solve what is known as *Haddock's Puzzle* (Haddock, 1987) automatically, even though it should not be too difficult to make it compatible with existing solutions from the literature (e.g. Champollion and Sauerland, 2011; Bumford, 2017).

second one.[24] Thus, the use of definite descriptions in examples like (25) may trigger some sort of Gricean implicature, since the anaphoric devices *par excellence*, i.e., personal pronouns, are avoided, which then stands in conflict to the observed impossibility of a self-standing use. This might also be the source for the following intuition (cf. Roberts, 2003: (40), p. 324):

(26) A woman entered from stage left. Another woman entered from stage right.
#The woman/✓The FIRST woman/✓The SECOND woman was carrying a basket of flowers.

The present systems allows for two parses that would render the use of the definite description felicitous. It could either reuse the variable contributed by the first ("a woman") or by the second indefinite description ("another woman"). What makes the choice for "the woman" worse than the alternatives mentioned by Roberts[25] seems to be exactly the same kind of indeterminacy as above, since (i) both possible antecedents fit in descriptive content, and (ii) the anaphorically used definite would not express something that could not be expressed by a simple "she" as well.[26] Thus, even though the sentence has a parse that would make it fine semantically, it might be ruled out for pragmatic reasons.

5. Conclusions and prospects

The present article has shown how a unified analysis of definite descriptions can be provided in a framework like FCS endowed with situation variables. It has not argued that this is the only analysis possible. As mentioned, Schwarz (2009) makes the case for an ambiguity between an anaphoric and a self-standing use based on languages that make morphological distinctions along these lines. A case in point may be the subtle difference in the following two forms of standard German:

(27) Ich war im / in dem Supermarkt.
I was in-the$_{\text{weak}}$ / in the$_{\text{strong}}$ supermarket.

The full-fledged, strong form of the definite article seems to be felicitous only in case it is used to refer back to a supermarket that is mentioned before; hence, if the definite is used anaphorically.[27] If the definite is used without antecedent, and hence uniqueness entailing, it must be in its reduced, weak form. The present analysis does not challenge this assessment. It complements it with a smooth alternative for languages where reasons for assuming an underlying

[24] What can be ruled out on the basis of classical binding theory is that both pick the same antecedent (or that the second definite anaphorically relates back to the first), since this would violate principle C. How binding theory is implemented in a dynamic framework is a different question, though. There are several remarks on this in Kamp and Reyle (1993), which are more thoroughly discussed in Berman and Hestvik (1994).

[25] Which pose their own problems since "first" and "second" (like "former" and "latter" and similar to "aforementioned") seem to refer to the order in which the women are mentioned and hence to a property of expressions rather than referents.

[26] Roberts claims that "she" instead of "the woman" unambiguously refers back to the second indefinite "another woman". If this is the case, there is a contrast between using personal pronouns and anaphoric definites whose descriptive content is matched by more than one antecedent. But then, one would expect an implicature to the end that the definite unambiguously refers back to the first indefinite description. Something like this has been claimed for d-pronouns in German (cf. Bosch et al., 2003), but the semantics for these pronouns seem to be more complicated (cf. Hinterwimmer, 2015).

[27] Ignoring deictical uses for the moment.

ambiguity cannot be provided as easily. If one wishes to do so, one can implement the two articles Schwarz proposes into the present system as well (recall that the uniqueness condition in (28b-(ii)) runs idle and can safely be omitted):

(28) a. (i) $[\![(\square^{weak} x_i)[\varphi]]\!]^d(G) = [\![\varphi]\!]^d(\{h : \exists g \in G : g \subset_{\{x_i\}} h\})$
(ii) $[\![(\square^{weak} x_i)[\varphi]]\!]^+(G) = \textsc{Unique}_{x_i}(G)([\![\varphi]\!]^+(\{h : \exists g \in G : g \subset_{\{x_i\}} h\}))$
b. (i) $[\![(\square^{strong} x_i)[\varphi]]\!]^d(G) = [\![\varphi]\!]^d(\{g \in G : g(x_i) \neq \#\})$
(ii) $[\![(\square^{strong} x_i)[\varphi]]\!]^+(G) = \textsc{Unique}_{x_i}(G)([\![\varphi]\!]^+(G))$

The next steps are rather obvious: iFCS needs to gain the capacity to deal with more than one situation variable at the same time in order to account for intensional environments proper and to implement Kaplanian two-dimensionalism in order to accout for deictical/referential uses of pronouns and definite descriptions. The "bookkeeping" device is severely complicated by multi-modalism partly because the presence of further situation variables seems to come with a whole new set of constraints (cf. Percus, 2000). Also, the meta-theoretical interpretation of assignment functions as representing indices demands that they are limited to one situational component; hence, multi-modal formulas depend on more than one file. Finally, the representation of contexts seems to be even more restricted so that further constraints are called for.[28]

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[28] The interested reader is referred to Köpping (2018), where I covered most of the topics just mentioned.

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