Postmodern Openings
ISSN: 2068-0236 | e-ISSN: 2069-9387
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2018, Volume 9, Issue 3, pages: 99-118 | doi: https://doi.org/10.18662/po/38

Intensionality, Reference and Games of Partial Information I. Intensional Transitive Verbs

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Abstract: In this paper I focus on the linguistic constructions in which intensional transitive verbs (ITVs) occur. In order to present the complex semantic profile of the ITVs, I contrast them with the extensional transitive verbs and I inspect the semantic differences of their inferential behaviour with respect to the existential entailment, to the substitution *salva veritate* of the coreferential terms and to the semantic specificity. Insofar as the sentences containing ITVs are structurally ambiguous between an intensional, *de dicto* interpretation, and an extensional, *de re* interpretation, they threaten the coordination between agents. For this reason, if the speaker uses an ITV in one way and the hearer's reading of it diverges from the speaker's intended meaning, both agents have a coordination problem. In this regard, using the mathematical framework of games of partial information, I show what conditions have to be satisfied in order for a rational speaker and a rational hearer to efficiently communicate with a sentence in which an ITV occurs and to converge on the right interpretation of the intensional verb construction, when the sentence's surface syntax is probabilistically silent about which of the *de re* or *de dicto* meaning the hearer has to choose in order to coordinate with the speaker. This is the first part of a two-part study.

Keywords: *Existential entailment; substitution salva veritate; interpretation de dicto; Nash equilibrium; Pareto efficiency; intensionality.*

How to cite: Hîncu, M. (2018). Intensionality, Reference and Games of Partial Information I. Intensional Transitive Verbs. *Postmodern Openings, 9*(3), 99-118. https://doi.org/10.18662/po/38

1. Introduction

The truth-values of the sentences representing the way in which things are, are constrained by it. In this regard, an extensional semantic policy states that, in case an ordinary syntactically well-formed sentence expresses a proposition, the truth-value of the proposition compositionally determined by the semantic contributions of the sentence's constituents and by their syntactic order, is fixed by the way in which things actually are. If the extension would deplete the meaning of all regions of discourse from a language, we would be constrained to mentally and linguistically represent only the way in which things actually are. But agents can think and can talk about many different ways, possible or impossible, in which things could be or in which they could have been. The basic ingredient which grounds the cognitive flexibility displayed by the agents' representations and which makes them capable of transcending, at the level of language and of cognition, the limits of the current states of affairs, is the intension (Abbott, 2010; Schwarz, 2015). Involved in many aspects of the agents' cognitive lives, it linguistically surfaces in the idiom which we exploit in order to state what the agents represent, what they refer to when they talk about something, what things or events they desire, imagine or hope for, what outcomes and states of affairs they predict, expect, simulate or fear, and so on. Insofar as the semantic values of the verbs which, in the previous sentence, expressed the agents' intentional attitudes, involve intensions, these transitive verbs belong to the class of the intensional verbs. In this sense, I focus, in this paper, on the linguistic constructions in which intensional transitive verbs (ITVs) occur.

In order to present, in the following section, the complex semantic profile of the ITVs, I will contrast them with the extensional transitive verbs and I will inspect the semantic differences of their inferential behaviour with respect to the existential entailment, to the substitution *salva veritate* of the coreferential terms and to the semantic specificity. Insofar as the sentences in which occur ITVs are structurally ambiguous between an intensional, *de dicto* interpretation, and an extensional, *de re* interpretation, they threaten the coordination between agents. For this reason, if the speaker uses an ITV in one way and the hearer's understanding of it diverges from the speaker's intended meaning, both agents have a coordination problem. To this end, using the mathematical framework of games of partial information, I will show, in the third section, what conditions have to be satisfied in order for a speaker and a hearer, which have common knowledge of their mutual

rationality, to efficiently communicate with a sentence in which an ITV occurs and to converge on the right interpretation of the intensional verb construction, when the sentence's surface syntax is probabilistically silent about which of the *de re* or *de dicto* meaning the hearer has to choose in order to coordinate with the speaker.

2. The Logical and Semantic Profile of ITVs

A transitive verb is a verb that, in the surface syntax of a sentence, is accompanied by a direct object. Assuming that a sentence's structure is typologically displayed by its constituents' order, a transitive verb is extensional just in case it validates *inter alia* the following inferences:

Existential Entailment:
S V O
O exists

Substitution:
S V O^1
$O^1 = O^2$
S V O^2

Specificity:
S V O
S V a particular O

A verb which admits interpretations invalidating at least one of the inferential schemes displayed above is an intensional one (Abbott, 2010, 2011; D'Ambrosio, 2017; Forbes, 2006, 2013; Moltmann, 1997, 2008; Recanati, 2000; Schwarz, 2015). The class of verbs which exhibit intensionality is divided into verbs which admit, in their object position, sentential complements, frequently noun clauses, and verbs whose non-sentential complements consist in noun phrases. Usually, the *intensional transitive verbs* (ITVs) nomenclature is reserved only for the latter verbs. The semantic peculiarities of an ITV can be best seen when its inferential behaviour is contrasted with that of a transitive verb which complies with the requirements of extensionality (Abbott, 2010, 2011; D'Ambrosio, 2017; Forbes, 2006, 2013; Moltmann, 1997; Schwarz, 2015). In this sense, consider the following sentence:

(1) Stephanie is reading a book.

In order to determine the truth-value of the above example, we have to consult the actual world and to measure how the sentence is representationally related with it. In case the referent of the subject phrase and the referent of the object phrase are in the relation encoded by the extensional transitive verb, the sentence (1) is true. Its truth is conditioned by the actual existence of both the entity denoted by the proper name and the entity denoted by the noun phrase (NP) occupying the object position of the verb in (1), and by the relation which holds between these entities. In case the sentence (1) is true, the ontological import of its NP validates the inferential pattern of existential entailment. In contrast, a sentence in whose surface syntax occurs an ITV has a reading for which the existence of the entity mentioned by the complement of the verb is not alethically decisive. Consider the following sentence:

(2) Stephanie imagines a society without war and poverty.

The sentence (2) can be true even though the entity denoted by the complement of its intensional verb doesn't actually exist. In this sense, the truth of (2) is insulated from the existence of the entity mentioned by the linguistic material which occupies the verb's object position. Insofar as the sentences with ITVs have readings in which the existence is semantically inert, they fail to inferentially generate existential entailment (Abbott, 2010, 2011; D'Ambrosio, 2017; Forbes, 2006, 2013; Moltmann, 1997; Schwarz, 2015). If we substitute a representational verb, like „think (about)", „refer (to)", „talk (about)", „represent", „portray", „draw" or „paint", for the verb which occurs in the sentence (2), the newly generated sentential contexts will also be unfriendly to existential quantification (D'Ambrosio, 2017; Moltmann, 1997, 2008; Schwarz, 2015).

Another semantic feature of ITVs which is made salient by the contrast with the extensional transitive verbs, concerns their semantic behaviour with respect to the substitution of semantically equivalent terms. Consider a situation which makes true the first of the following two sentences:

(3) Stephanie admires the woman
who received the Nobel Peace Prize in 1979.
(4) Stephanie admires the youngest child
of Nikolle and Dranafile Bojaxhiu.

The intensional NP-complements of the verbs occurring in (3) and (4) are definite descriptions. Considered independently of the above particular sentential embeddings and used referentially, both descriptions have, with regard to the actual world, the same extension. In case the referent of the subject phrase from the sentence (3) does not know that both descriptions refer to the same person, namely Mother Teresa, the substitution of the definite description which occurs in (4) for the definite description which occurs in (3) does not preserve the truth-value of the initial sentence. In this scenario, the sentence (4) will be a false one, even though (3) is a true sentence. Likewise, the sentence (2), in case it is true, admits a reading in which substituting, in its verb phrase (VP), the indefinite NP „a golden mountain", whose extension is the empty set, for the extensionally equivalent indefinite, makes the following sentence false:

(5) Stephanie imagines a golden mountain.

What the last examples show is that an ITV permits readings in which the substitution *salva veritate* of the coextensional items, in the verb's complement, is blocked. In this sense, the intensional verbal constructions are referentially opaque in object position (Abbott, 2010, 2011; D'Ambrosio, 2017; Forbes, 2006, 2013; Kaplan, 1968; Moltmann, 1997; Quine, 1956; Recanati, 2000; Schwarz, 2015). In contrast, the sentences formed with extensional transitive verbs never license readings which violate the inferential pattern of substitution. Consider the following example:

(6) Desmond Tutu met Dalai Lama.

Insofar as the referents of both proper names which occur in the sentence (6) have met in the actual world, (6) is contingently true. Its truth is preserved in spite of the substitution, in the complement of the extensional verb, of a coreferential expression, like „Tenzin Gyatso", for the proper name whose occurence in (6) denotes the 14th and current Dalai Lama, and in consequence, the following sentence will also be true:

(7) Desmond Tutu met Tenzin Gyatso.

As the complements of the extensional transitive verbs do not resist the substitution *salva veritate* of the coreferential expressions, these verbs are, in contradistinction to ITVs, referentially transparent in object position

(Abbott, 2010, 2011; D'Ambrosio, 2017; Forbes, 2006, 2013; Moltmann, 1997; Quine, 1956; Recanati, 2000; Schwarz, 2015).

Another logical aspect which differentiates the semantic behaviour of the ITVs from that of the extensional transitive verbs is emphasized by the assessement of the responses which the verbs elicit with regard to the specificity inference. Consider the next sentence:

(8) Stephanie is looking for a book.

The sentence (8) can receive two interpretations with different truth-conditional profiles. There is an interpretation of (8) on which the sentence's truth requires the intensional NP-complement to have one satisfier and only one, a particular one. But the sentence (8) also licenses an interpretation on which this requirement is not imposed. As the failure of existential quantification has already shown, in order for a sentence in which an ITV occurs, like (8) above, to be true, its intensional NP-complement does not even require a satisfier. But in case the extension of the verb's complement is not empty, the truth of the sentence in which the intensional complement is embedded does not demand a particular satisfier. In this sense, the indefinite NP which occupies the object position of the intensional verb in (8) does not call for one specific satisfier and, in consequence, the sentence allows an interpretation on which its truth is compatible with many complement's satisfiers. An interpretation of this type is never licensed by the sentences whose transitive verbs are extensional. Consider the following example:

(9) Stephanie is reading a book.

With regard to the sentence (9), there is an intuition according to which (9) is true if and only if its indefinite NP has a particular satisfier. This intuition is well motivated by the linguistic data which show that the environment created by an extensional transitive verb does not tolerate expressions which semantically induce non-specificity (D'Ambrosio, 2017; Forbes, 2006, 2013; Moltmann, 1997, 2008; Schwartz, 2015). In this sense, a sentence like the following is meaningless:

(10) Stephanie is reading a book, but not a particular one.

To the extent that expressions indicating the non-specificity, like „no particular one" and „any will do", can be succesfully appended to the

intensional verbal constructions, there is evidence that ITVs, in contrast to extensional transitive verbs, permit a supplementary interpretation on which the specificity condition is not satisfied (D'Ambrosio, 2017; Forbes, 2006, 2013; Moltmann, 1997, 2008; Schwartz, 2015).

Insofar as the interpretations assigned to the sentences in which intensional verbal constructions are embedded, like (8) above, have different truth-conditional profiles, this constitutes support for the hypothesis according to which the sentences of this kind are structurally ambiguous between a specific and a non-specific interpretation (Abbott, 2010; D'Ambrosio, 2017; Forbes, 2006, 2013; Moltmann, 1997, 2008; Quine, 1956; Schwarz, 2015). Only the latter interpretation, usually called *de dicto* or *intensional* interpretation, is what differentiates the semantic behaviour of the ITVs from that of the extensional transitive verbs. The contrast between the *de dicto*, intensional interpretation of ITVs, and their *de re*, extensional interpretation, which the intensional and the extensional verbs have in common, is represented by means of the logical notion of scope (Abbott, 2010; D'Ambrosio, 2017; Forbes, 2006, 2013; Kaplan, 1968; Moltmann, 1997, 2008; Quine, 1956; Recanati, 2000; Schwarz, 2015).

On the *de re* interpretation of the sentence (8), the intensional verb takes narrow scope while the indefinite, logically considered outside the scope of the verb, generates the specific reading according to which there is a particular book which the referent of the proper name from (8) is looking for. In contrast, on the *de dicto* interpretation of the same sentence, the intensional verb of (8) logically governs the interpretation of the indefinite NP which, this time, takes narrow scope with respect to the verb and generates a non-specific reading according to which, in case the intensional NP has satisfiers compatible with what the referent of the subject phrase of (8) is looking for, he is not looking for a particular book, but for some book or other. In this regard, if we substitute a verb of absence, like „desire", „want", „lack" or „need", for the verb which occurs in the sentence (8), the newly generated sentential contexts will also allow readings which semantically induce non-specificity (D'Ambrosio, 2017; Moltmann, 1997, 2008; Schwarz, 2015).

3. Games of Partial Information and ITVs

In the previous section we have seen that the sentences in which occur ITVs are structurally ambiguous between an intensional, *de dicto* interpretation, and an extensional, *de re* interpretation. Insofar as sentences of this type are ambiguous, they threaten the coordination between agents.

In this sense, if the speaker uses an ITV in one way and the hearer's reading of it diverges from the speaker's intended meaning, both agents have a coordination problem. In this section, I offer a game-theoretical model which explains how both the speaker and the hearer can rationally avoid miscommunication, and how they can optimally solve their coordination problem, on the intended meanings of the utterances of sentences consisting of ITVs, in a systematic way. In this regard, I will use the mathematical framework of games of partial information elaborated by Parikh in (Parikh, 1991, 2000, 2001, 2007, 2010) and presented in (Clark, 2012; Ross, 2011; Van Rooy, 2004). In what follows, I will show what are the conditions that have to be satisfied in order for a rational speaker and a rational hearer to efficiently communicate with a sentence consisting of an ITV and to optimally converge on its interpretation when the sentence's surface syntax is probabilistically silent about which of the *de re* or *de dicto* meaning the hearer has to choose in order to coordinate with the speaker.

Take a look at the following context. Stephanie believes, without any particular reason, that the philosophers are the smartest people in the whole world and she desires to marry only smart people. The only philosopher she actually knows is Mikhael, a man who secretly loves her and who intends to propose to her. One day, talking with her sister June about Stephanie, Mikhael hears June uttering the following sentence:

(11) Stephanie desires to marry a philosopher.

How should Mikhael understand what the utterance of the sentence (11) means? More precisely, should he assign to the utterance of (11) an intensional, *de dicto* interpretation, or an extensional, *de re* one?

In what follows, I let *S* and *H* denote the speaker and the hearer of the above context and I assume that both agents *S* and *H* are rational. In order to understand *H*'s choice problem, the following thought experiment will help to clarify what each interpretation of the sentence (11) entails. In this regard, let's consider a modal space which consists of just two possible worlds w_1 and w_2. Also, let's consider that what the intensional verb from the sentence (11) encodes, motivates a behavioural response of the referent of the subject phrase in relation to the referent of the object phrase. Assume, for simplicity, that there are only two such behavioural responses, one involving the acceptance of a marriage proposal, another involving its rejection.

The thought experiment invites us to observe whether the behavioural response of the referent of the subject phrase from (11), varies

across w_1 and w_2 or it is uniform. We know from the above that in the actual world w_1 there is a satisfier of the intensional NP-complement of (11), more precisely, the individual *H* who has the property of being a philosopher. From a metaphysical viewpoint, being a philosopher is a property that *H* contingently instantiates. This basically means that *H*, who actually instantiates this property, doesn't necessarily possess it and, in consequence, that there is another point in the modal space at which *H* lacks the property of being philosopher. In this sense, consider that in the possible world w_2 it is the case that the actual satisfier *H* of the intensional NP-complement of (11), has the property of being a mathematician.

In case the semantic value of the intensional verb of the sentence (11) would motivate, in the possible world w_2, a behavioural response which differs from the one elicited, in the actual world w_1, by the referent of the subject phrase with regard to the referent of the object phrase, only the intensional, *de dicto* interpretation of (11) would be compatible with this case. In this sense, *H* knows that in case *S* speaks truthfully and intends to determine him, by uttering the sentence (11), to interpret it in a *de dicto* way, Stephanie desires to marry him only in the actual world w_1. Hence, insofar as in the possible world w_2 Stephanie does not desire to marry *H* and he knows that, he will also know that her behavioural response, which would involve in w_2 a rejection of his proposal to her, is not consistent across the modal space.

In case that in both possible worlds w_1 and w_2 the semantic value of the ITV which occurs in the sentence (11) would motivate, with regard to the referent of the object phrase, the same behavioural response from the referent of the subject phrase, only the extensional, *de re* interpretation of (11) would be compatible with this case. In this regard, *H* knows that in case *S* intends to determine him to assign to the sentence (11) a *de re* meaning, Stephanie's behavioural response, which this time would involve an acceptance in w_2 of his marriage proposal, is consistent across the possible worlds w_1 and w_2.

Even though *H* knows that both the *de dicto* and the *de re* interpretation of (11) are compatible with Stephanie's future acceptance, in w_1, of his intended marriage proposal to her, he wants to know whether he is counterfactually desired as husband. Being a rational agent, *H* would not be happy knowing that Stephanie's desire to marry him is conditioned by his contingent property of being a philosopher and, as such, that her desire toward him is not constant across the modal space.

H's interpretative uncertainty with regard to the sentence (11) also impacts his decision-making process. In this sense, his decision to propose

to her depends on which interpretation of (11) is true: if the intensional, *de dicto* interpretation of (11) is true, then he chooses to abandon the marriage proposal, but if the extensional, *de re* interpretation of (11) is the true one, then *H* chooses to ask Stephanie to marry him. Hence, his right decision depends on whether he can optimally reduce his interpretative uncertainty induced by the utterance of the ambiguous sentence (11), which in turn depends on how well he coordinates with *S* on the intended meaning of (11).

In what follows I will show, using the mathematical framework of games of partial information, what are the conditions that have to be satisfied in order for the rational agents, like *S* and *H* above, to efficiently communicate with a sentence in which an ITV occurs, when the sentence's surface syntax is probabilistically silent about which of the *de re* or *de dicto* meaning the hearer has to choose in order to coordinate with the speaker. From now on, where the symbol u_1 stands for the utterance of the above sentence (11), let m_1 abbreviate the *de dicto* meaning of u_1 and let m_2 abbreviate its *de re* meaning. Also, consider that s_i, where $1 \leq i \leq 2$, denotes one of the speaker's information states.

After *H* hears *S* uttering u_1, *H* knows that there is a probability p_1 of *S* being in an information state s_1 characterized by the referential intention of expressing m_1, and a probability p_2 of *S* being in another information state s_2 characterized, this time, by the referential intention of expressing m_2. Insofar as only *S* knows her referential intention, it is common knowledge to both agents *S* and *H* that the latter doesn't know which of the two information states s_1 and s_2 is the factual one (Clark, 2012; Parikh, 1991, 2000, 2001, 2007, 2010; Ross, 2011; Van Rooy, 2004).

Even though *H* is not able, at this point of their strategic interaction, to recognize the referential intention of *S*, *H* knows that *S* might have chosen to linguistically signal the particular meaning she intends to convey in an explicit way, using an alternative to the linguistic form (11). In this sense, *H* knows that, in order to clarify that her referential intention is oriented towards the interpretation corresponding to m_1, *S* might have uttered a sentence in which the intensional verb construction would have been accompanied by an expression which semantically induces non-specificity, like the following:

(12) Stephanie desires to marry a philosopher, not a particular one.

In the same vein, *H* knows that, in case *S* might have wanted to determine him to believe that he enjoys the modal exclusivity of Stephanie's

desire, *S* also might have chosen to utter, instead of the sentence (11) she actually uttered, an alternative sentence, like the following:

(13) Stephanie desires to marry a philosopher
whom she already knows.

From now on, let u_2 abbreviate the utterance of the sentence (12) and let u_3 abbreviate the utterance of the sentence (13). As a consequence of the rationality exhibited by both agents *S* and *H*, all of the above counterfactual linguistic choices and inferences are common knowledge to them (Clark, 2012; Parikh, 1991, 2000, 2001, 2007, 2010; Ross, 2011; Van Rooy, 2004). Also, the fact that *S* knows that her possible actions induce different information states in *H*'s cognitive model of their strategic interaction, is common knowledge to both *S* and *H*. Consider that the symbol t_j, where $1 \leq j \leq 4$, stands for one of the hearer's information states.

H knows that in case *S* would choose to utter u_2, her choice would place *H* in an information state t_1 in which he could clearly recover *S*'s referential intention of expressing the meaning m_1. Hence, in case s_1 would be the factual information state of *S*, *H* would be able to infer from his information state t_1 that this is indeed the case and, in consequence, that Stephanie's desire towards him varies across the modal space. *H* also knows that if the information state s_1 would be the factual one, then the set of his information states would contain, beside t_1, another information state t_2, this time induced by the *S*'s actual choice of uttering u_1, a state from which *H*, recognizing that *S*'s referential intention is oriented towards the *de dicto* interpretation of u_1, would be able to safely infer that Stephanie does not desire to marry him in the possible world w_2. Being a rational agent, *H* is aware that the speaker's choice of uttering u_1 is also compatible with the epistemic scenario in which *S*'s factual information state is s_2. In this regard, *H* knows that if this possibility were actual, then *S*'s action of uttering u_1 would induce, in his cognitive model of their interaction, an information state t_3 in which he would process u_1 as expressing a *de re* meaning, and on that basis, he would infer that Stephanie desires to marry him in both w_1 and w_2. Insofar as *H* knows that the speaker's referential intention of expressing the meaning m_2 can also be materialized in her choice of the utterance u_3, *H* knows that this possible action of *S* would place him in an information state t_4 from which he would be able to soundly infer that s_2 is the factual information state of *S*.

As the above description shows, in case the factual information state of *S* is s_1, there are in the cognitive model of *H* two information states,

namely t_1 and t_2, in which he can recognize that the referential intention of *S* is to linguistically signal the meaning m_1. Likewise, in case s_2 is the factual information state of *S*, the cognitive model of *H* makes room for the information states t_3 and t_4 from which he is able to recognize that the referential intention of *S* is to express the meaning m_2. While *H* can successfully differentiate his information state t_1 from his information state t_4, he is epistemically indeterminate between the information state t_2 and the information state t_3, and this fact is common knowledge to both agents *S* and *H* (Clark, 2012; Parikh, 1991, 2000, 2001, 2010; Ross, 2011). In this sense, the hearer's cognitive inability is the result of the speaker's actual choice to utter the sentence (11) whose intensional verb construction induces structural ambiguity between the *de dicto* meaning m_1 and the *de re* meaning m_2.

In case *H* would know which of his information states t_2 and t_3 is factual, he would know which of the speaker's *S* information states s_1 and s_2 is factual, and in consequence, he would know which of the two meanings m_1 or m_2 coheres with *S*'s referential intention (Clark, 2012; Parikh, 1991, 2000, 2001, 2010). What *H* knows instead is that if his information state t_2 is factual, then he fails to coordinate with *S* in case he chooses to assign to the utterance u_1 an extensional, *de re* interpretation. In the same vein, *H* knows that if t_3 is the factual information state and he chooses to assign to the utterance u_1 an intensional, *de dicto* interpretation, the agents' coordination is also compromised. In this regard, insofar as *S* knows her referential intention, *S* is the only agent in this game knowing which of the information states s_1 and s_2 is factual, and in consequence, *S* is the only one who knows, after she chooses to utter the ambiguous sentence (11), which of *H*'s information states t_2 and t_3 is the factual one. The entire structure of the above strategic interaction and the fact that it involves asymmetric information are common knowledge to both agents *S* and *H* (Clark, 2012; Parikh, 1991, 2000, 2001, 2010).

In order to show what conditions have to be satisfied in order for the rational agents *S* and *H* to coordinate on the intended interpretation of an utterance of a sentence in which occurs an ITV, the agents' strategies cannot be disregarded. Informally, a strategy is a complete contingent map of actions which serves an agent to orient him in the course of the game he plays (Watson, 2013). In this sense, a strategy specifies all the available choices of an agent with respect to each of his information states. More technically, in an extensive-form game, a strategy is a function from the set of all the sets of the information states of an agent to the set of the actions that the agent can choose (Parikh, 1991, 2000, 2001, 2010). In the present

case, the strategies of the speaker S and of the hearer H, displayed below, also constitute an ingredient of their common knowledge:

(S_1) $(s_1 \rightarrow u_1, s_2 \rightarrow u_1)$
(S_2) $(s_1 \rightarrow u_2, s_2 \rightarrow u_1)$
(S_3) $(s_1 \rightarrow u_1, s_2 \rightarrow u_3)$
(S_4) $(s_1 \rightarrow u_2, s_2 \rightarrow u_3)$

(H_1) $(t_1 \rightarrow m_1, \{t_2, t_3\} \rightarrow m_1, t_4 \rightarrow m_2)$
(H_2) $(t_1 \rightarrow m_1, \{t_2, t_3\} \rightarrow m_2, t_4 \rightarrow m_2)$

At the present stage of the game, in order to optimally solve their coordination problem, both S and H have to take into consideration the possible utterances u_2 and u_3 of the alternative linguistic forms (12) and (13), and to scale their efficiency against the utterance u_1 of the sentence (11). In this regard, in contrast to the utterance u_1 of the sentence (11) which exhibits structural ambiguity between the intensional, *de dicto* meaning m_1, and the extensional, *de re* meaning m_2, the utterances u_2 and u_3 succeed to unambiguously signal the referential intention of S and allow H to transparently infer that his information state would be t_1, in case u_2 would be uttered, or that his information state would be t_4, assuming that u_3 would be uttered. Even though the utterance u_2, which exclusively expresses the meaning m_1, places H in the epistemic position to infer that s_1 is the factual information state of S, u_2 is costlier than u_1 with respect to its production and its processing effort. Likewise, the utterance u_3, which linguistically signals only the meaning m_2 and which gives H the epistemic ground to infer that the factual information state of S is s_2, is longer than u_1 and so involves additional costs.

Insofar as both S and H are rational agents, they prefer to coordinate on the intended interpretation of the ambiguous utterance u_1 and this fact is common knowledge to both of them. Also, in case S and H would successfully converge on the communicated meaning, they would prefer to minimize the producing and processing efforts involved in their linguistic interaction, and in consequence, their preferences would be biased towards shorter and more economical linguistic forms, instead of longer and costlier ones (Clark, 2012; Parikh, 1991, 2000, 2001, 2010; Ross, 2011; Van Rooy, 2004). Likewise, in order to avoid the risk of miscommunication, both agents S and H would prefer to pay the price of using less economical linguistic forms which, in spite of their greater complexities and costs, succeed to secure the agents' successful communication (Clark, 2012; Parikh, 1991, 2000, 2001, 2010; Ross, 2011; Van Rooy, 2004).

Insofar as the payoffs, which are determined by the agents' combined choices and which allow to assess how successful is the communication of a piece of information in relation to the costs of producing and processing it, are measurable on a utility scale, all the above preferences, which are common knowledge to both the speaker and the hearer, can be mathematically translated into a numerical scale of utilities (Parikh, 1991, 2000, 2001, 2010). As usual, the utilities are defined over the profiles of strategies, where a strategic profile is, in the present example, a 2-tuple consisting of one of the speaker's strategies and one of the hearer's strategies. In this sense, let a_S and a_H be the utilities of S and H in case H assigns to the unambiguous utterance u_2 the meaning m_1. Let b_S and b_H be the agents' utilities if H assigns to the ambiguous utterance u_1 an intensional, *de dicto* interpretation, when S has the referential intention to express m_1. Let c_S and c_H be the payoffs of both agents if H incorrectly assigns to u_1 an extensional, *de re* interpretation, when the factual information state of S is s_1. Likewise, let d_S and d_H be the utilities of S and H if H incorrectly assigns to the ambiguous utterance u_1 an intensional, *de dicto* interpretation, when S has the referential intention to express m_2 by uttering u_1. Let e_S and e_H be the agents' utilities if H assigns to u_1 an extensional, *de re* interpretation, when S's factual information state is s_2. Finally, let f_S and f_H be the payoffs of S and H in case the latter assigns to the unambiguous utterance u_3 the meaning m_2. The utilities assigned to the profiles of agents' strategies, in the information states s_1 and s_2, are displayed below in the tables 1 and 2.

As it can be observed from these two tables, when the coordination of the speaker and the hearer on the intended interpretation of the utterance u_1 obeys the least effort, they receive the following utilities: b_S, b_H, e_S, e_H. Likewise, in case their linguistic coordination, in spite of its success, involves greater effort, their payoffs are: a_S, a_H, f_S, f_H. The remaining utilities c_S, c_H, d_S, d_H translate the penalties of S and H induced by their failure to communicate.

Table 1. The utilities of the strategic profiles in s_1

s_1	H_1	H_2
S_1	b_S, b_H	c_S, c_H
S_2	a_S, a_H	a_S, a_H
S_3	b_S, b_H	c_S, c_H
S_4	a_S, a_H	a_S, a_H

Table 2. The utilities of the strategic profiles in s_2

s_2	H_1	H_2
S_1	d_S, d_H	e_S, e_H
S_2	d_S, d_H	e_S, e_H
S_3	f_S, f_H	f_S, f_H
S_4	f_S, f_H	f_S, f_H

All the above utilities satisfy the following rational constraints and this fact is common knowledge to both *S* and *H* (Parikh, 2010: 94-95):

$b_S > a_S > c_S$
$e_S > f_S > d_S$
$b_H > a_H > c_H$
$e_H > f_H > d_H$

In order to find the solution concept of the game of partial information which models here a linguistic strategic interaction in which the agents' coordination is threatened by the ambiguity induced by the utterance of an intensional transitive construction, the expected utilities corresponding to each profile of agents' strategies have to be computed. In this regard, where p_1 is the probability that *S* is located in the information state s_1 in which she has the referential intention of expressing m_1, and p_2 is the probability that she is located in the information state s_2 in which she has the referential intention of expressing m_2, the expected utilities of the agents' combined choices are depicted in the following tables.

Table 3. The expected utilities of the profiles (I)

EU	H_1
S_1	$p_1b_S + p_2d_S, p_1b_H + p_2d_H$
S_2	$p_1a_S + p_2d_S, p_1a_H + p_2d_H$
S_3	$p_1b_S + p_2f_S, p_1b_H + p_2f_H$
S_4	$p_1a_S + p_2f_S, p_1a_H + p_2f_H$

Table 4. The expected utilities of the profiles (II)

EU	H_2
S_1	$p_1c_S + p_2e_S, p_1c_H + p_2e_H$
S_2	$p_1a_S + p_2e_S, p_1a_H + p_2e_H$
S_3	$p_1c_S + p_2f_S, p_1c_H + p_2f_H$
S_4	$p_1a_S + p_2f_S, p_1a_H + p_2f_H$

As the tables above highlight, if we try to determine, in the present game of partial information, the conditions under which is secured the agents' convergence on the right interpretation of the ambiguous utterance u_1, then the appeal to the most classical solution concept used in game theory, namely the famous Nash equilibrium, would not be enough. In this regard, applying only the concept of Nash equilibrium to the present game is not very useful insofar as the data from the above tables show that there are two optimal strategic profiles in which neither agent has any interest to change his choice while the play partner strategically stick to his guns. Indeed, the two strategically safe positions in the game, in which *S* and *H* do their best, correspond to the strategic profile (S_3, H_1) and to the strategic profile (S_2, H_2).

In conformity with the first Nash equilibrium, *S* should utter u_1 just in case she is located in the information state s_1, while *H* should grasp the utterance's *de dicto* meaning m_1 and thus should understand that Stephanie's desire to marry him is not uniform across the modal space. Also, this optimal strategic profile predicts that *S* would reserve the unambiguous utterance u_3, which transparently indicates that her referential intention is attuned to the *de re* meaning m_2, for the case in which she would be located in the information state s_2.

The second Nash equilibrium dictates that *S* should use the same utterance u_1 just in case she is located in the information state s_2, while *H* should understand, this time, the utterance's *de re* meaning m_2 according to which, in all the possible worlds w_1 and w_2, Stephanie desires to marry only him. This optimal strategic profile also shows what would *S* do in case she would be counterfactually located in the information state s_1. In this regard, (S_2, H_2) predicts that *S* would use, in order to communicate to *H* that her referential intention is attuned to the *de dicto* meaning m_1, the unambiguous utterance u_2.

All the above predictions generated by each equilibrium point of the game and the structure of the strategic interaction of *S* and *H*, are common knowledge to both agents (Clark, 2012; Parikh, 1991, 2000, 2001, 2010; Ross, 2011; Van Rooy, 2004). But all this knowledge does not ensure yet that *S* and *H* succeed in their effort to converge on the right interpretation of the utterance u_1 and thus solve the ambiguity induced in their communication by the use of an intensional construction.

In order to solve games of partial information, like the one above played by *S* and *H*, a unique solution concept has to be identified. In this regard, it helps to bet on the rational behaviour of the agents who choose, in tandem, only those strategies which ensure the maximization of their expected utilities. Insofar as in the game examplified above only one of the two strategic profiles (S_3, H_1) and (S_2, H_2) pays to *S* and *H* more than the other, the unique solution concept of the game, that which both agents select and which guarantees that their communication with an ambiguous utterance of a sentence in which occurs an ITV is successful, corresponds to the Nash equilibrium which passes the Pareto dominance test, yielding the highest expected utility (Clark, 2012; Parikh, 1991, 2000, 2001, 2007, 2010; Ross, 2011; Van Rooy, 2004). Its existence is mathematically guaranteed by the following systematic relations, presented in (Parikh, 2010: 95-96), between the expected payoffs of a strategic profile apt to be a Nash equilibrium and the expected payoffs of the other Nash-eligible profile. In this regard, in case the expected utilities of the strategic profiles (S_3, H_1) and (S_2, H_2) satisfy at least one of the conditions (C_1) and (C_2) displayed below

$$(C_1) \quad \begin{array}{l} p_1 b_S + p_2 f_S > p_1 a_S + p_2 e_S \\ p_1 b_H + p_2 f_H \geq p_1 a_H + p_2 e_H \end{array}$$

$$(C_2) \quad \begin{array}{l} p_1 b_S + p_2 f_S \geq p_1 a_S + p_2 e_S \\ p_1 b_H + p_2 f_H > p_1 a_H + p_2 e_H \end{array}$$

then, the strategic profile (S_3, H_1) is the unique Pareto-Nash equilibrium of the game of partial information used here to model the communication involving utterances of intensional transitive constructions. Likewise, in case the expected utilities corresponding to the optimal strategic profiles (S_3, H_1) and (S_2, H_2) satisfy at least one of the conditions (C_3) and (C_4) presented below

(C_3) $p_1a_S + p_2e_S > p_1b_S + p_2f_S$
$p_1a_H + p_2e_H \geq p_1b_H + p_2f_H$

(C_4) $p_1a_S + p_2e_S \geq p_1b_S + p_2f_S$
$p_1a_H + p_2e_H > p_1b_H + p_2f_H$

then, the profile of strategies (S_2, H_2) will be the unique Pareto-Nash equilibrium of the present game. As it can now be seen, when the utilities assigned to the profiles of agents' strategies, in the information states s_1 and s_2, take values which respect the following equations

$b_S - a_S = e_S - f_S$
$b_H - a_H = e_H - f_H$

the problem of finding the unique solution concept to the game of partial information which models the coordination on the interpretation of an utterance of a sentence with an ITV, is reduced to the assessment of the probabilities of the speaker's information states s_1 and s_2, and *a fortiori* to the hearer's assessment of the probabilities of the information states t_2 and t_3 (Parikh, 2010: 96).

Therefore, the communication with u_1 is successful in the information state s_1 only when s_1 is factual, and so the probability of S being located in s_1, respectively, the probability of H being located in t_2, surpasses the probability of the former's location in the information state s_2, respectively, the probability that the latter is located in t_3, in which case the common knowledge of all that ensures that (S_3, H_1) is the Pareto-Nash equilibrium of the game. Likewise, the communication with u_1 will be successful in the information state s_2 only when s_2 is factual, and so the probability that S is located in s_2, respectively, the probability that H is located in t_3, is greater than the probability of the former's location in the information state s_1, respectively, than the probability of the latter's location in t_2, in which case the common knowledge of the game's structure ensures that its unique solution is the strategic profile (S_2, H_2), the only Nash equilibrium of the game which respects the condition of Pareto efficiency.

4. Conclusions

In this paper I have focused on the linguistic constructions in which ITVs occur. To present the semantic profile and the inferential peculiarities of the ITVs, I have compared them with the extensional transitive verbs and

I have examined the verbs' differences in semantic behaviour. In this sense, I have shown that the sentential contexts embedding ITVs allow readings which, insofar as the intensional NP-complements lack existential import, make the intensional VP-constructions unfriendly to existential quantification. Also, I have assessed the semantic behaviour of the ITVs with respect to the substitution of the extensionally equivalent terms, and I have shown that, in contradistinction with the extensional transitive verbs, which are referentially transparent in object position, the ITVs allow interpretations in which their object positions are referentially opaque and resist the substitution of coreferential expressions. Likewise, I have shown that, insofar as the ITVs allow readings which semantically induce non-specificity, the sentences in which they occur are structurally ambiguous between an intensional, *de dicto* interpretation, and an extensional, *de re* interpretation. Insofar as in the communication situations involving sentences in which ITVs occur, the hearers' interpretations can diverge from the speakers' intended meanings, the ambiguity of the ITVs generates coordination problems for the interacting agents. To explain how the agents can optimally solve their linguistic coordination problem, I have used the mathematical framework of games of partial information. To this end, I have game-theoretically framed the conditions which ensure the success of communication, between a speaker and a hearer, with a sentence in which an ITV occurs, and which guarantee that, insofar as both agents have common knowledge of their mutual rationality, their coordination problem, on the right interpretation of the ambiguous intensional verb construction, always has a unique solution.

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