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Logical Interpretation of Omissive Implicature

Alfonso Garcés-Báez and Aurelio López-López

Abstract Implicature is a linguistic concept allowing inferences about what is said during interaction. However, it differs from an implication in that does not involve a definition or truth tables in a logic. In particular, an omissive implicature leads to inferences about what is omitted or not said. Omission in linguistic terms brings us to the intention of remaining silent about something by whatever reason. That is, omission is the word that is not uttered. In this research, a semantics was formulated to explain omission in testimonies, as well as in the context of dialogues, where its role is common. In testimonies, we achieved a logic-based knowledge representation, allowing reasoning through Answer Set Programming. These allowed to generate models illustrating the implications of silence in several logical-linguistic puzzles. Puzzles were taken as case study given that they state, in simple or everyday language, common situations, requiring the use of arithmetic, geometry, or logic, for its solution. In dialogues, a procedure was developed to make decisions, based on answers and a record (knowledge base) of the occurrences of omission, while maintaining the communication process. The procedure was oriented to psychotherapy interviews, where the Beck Inventory was extended to include silence, to assess the degree of depression of a person.

1 Introduction

Silence can have different meanings in specific contexts. For example, in some communities, such as that of the North American Indians of the Apache reservation, a kind of quarantine of silence is maintained for those who come to their community after have been outside. There is an intimate relationship between silence and music,

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it has been said that music expresses what cannot be said with words but cannot remain silent (Victor Hugo). The music is not in the notes, but in the silence between them (W. Amadeus Mozart). After silence, what comes closest to expressing the inexpressible is music (Aldous Huxley). Calm and quiet people have the loudest and loudest minds (Stephen Hawking). The norms and social distance influence the interpretation of silence, as far as we know, in Japanese society, no inferences are made from condescending silence, known in ours as the one who silences grants. Silence can also be scary, as Pascal said: *The silence of infinite spaces frightens me*.

Here is a fragment of a text that narrates the shipwreck of the ship El Tritón [16]:

…But there it was: there were the throatless howls of the cyclone.
The radio operator leaned gently toward the set. His voice was suddenly flat, professional.
-Veracruz. Veracruz. Veracruz. Change!
They responded, from who knows what point, from who knows what corner of the cosmos, some inhuman screams, throats slashed, a dentist's electric drill, dogs with hydrophobia, snoring, someone scraping glass with sand. The operator pushed the lever. SILENCE.
- There's a lot of static. They don't hear me," he said calmly. He wiped his sweaty hands on his legs.
- Are you afraid ?—Asked the boatswain without knowing why he was asking this question. Perhaps because of hands soaked in sweat. The telegraph operator smiled. "Yes," he replied with the same calm.
He leaned over the apparatus again:
- Veracruz! Veracruz! Veracruz!
…

Silence is the sign of a mysterious message whose apparent emptiness feeds on the reality of those who live it, devours their temporary space, far, far away from the possibility of being occupied by words. As Stainer says: How can speech justly convey the form and vitality of silence?

The silence was before the word. Man, for Aristotle (384 BC-322 BC), is the being of the word. How did the word reach man? It is something that, as Socrates warns in the Cratylus: *It is an enigma, it is not a question whose sure answer is within the reach of humans*. Will man also be the being of silence as he is of the word?

As for what we cannot speak, we must remain silent, said Wittgenstein. Language can only meaningfully deal with a particular and restricted segment of reality. The rest—and, presumably, most of it—is silence.

Most conceptualizations of silence tackle it as a relatively passive behavior. However, not every manifestation of silence represents passive behavior and is not simply the opposite of voice. Speech and silence are two dialectical ingredients to achieve an effective communication.

1.1 Problem Statement and Hypothesis

Omission or intentional silence is a phenomenon barely studied from a computational point of view whose interpretation can benefit communication processes, particularly in the interaction during the dialogue, and can help decision-making.

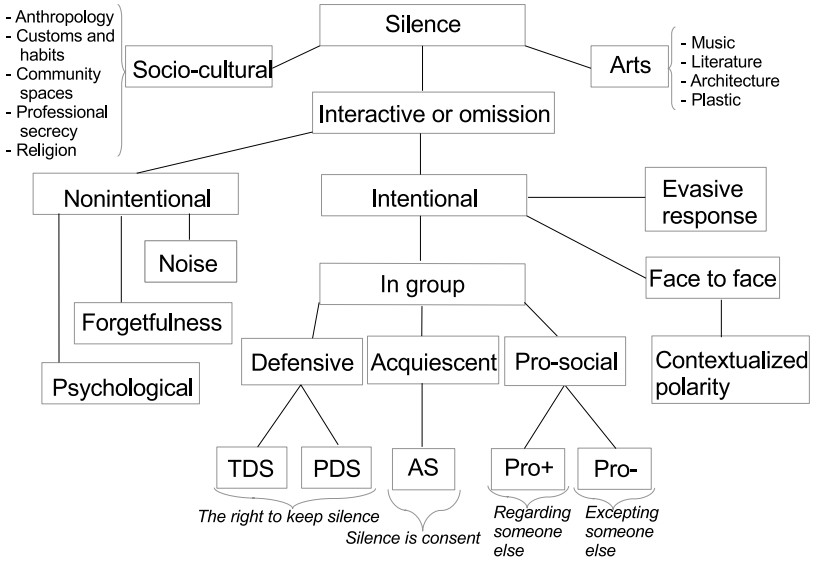


Fig. 1 Some contexts where silence appears

Problem Statement:
The problem consists of automating the interpretation of the omission or intentional silence in written interactions under the contexts of testimonies and dialogue to make inferences without breaking the communication.
Hypothesis:
The logical interpretation of the omission implicature contributes elements to the communicative process and helps decision-making.

2 Theoretical Basis

Now, we detail some definitions for implicature and omission, considering also concepts provided previously. Given that everybody regularly recurs to silence or omission, the possible interpretations can increase; however, researchers have tried to fully understand the meaning of silence, sharing the advances.

Given that silence is a human behavior, it appears in music, art, philosophy, literature, architecture, and a wide variety of disciplines (Fig. 1).

In this section, we show also some concepts around silence, useful for our research.

2.1 Implicature

Our definition of omission implicature is based on Grice's definition of conversational implicature, formalized in the Stanford Encyclopedia of Philosophy [20].

2.2 Answer Set Programming

Answer Set Programming (ASP) is a computing approach where different computational problems can be formulated to obtain sets of answers from logic programs. This paradigm has been used to solve diverse tasks, from configuring computer systems or programming decision support systems for the space shuttle to tackling problems that arise in linguistics and bioinformatics [13].

The basis of ASP is on deductive databases, logic programming, knowledge representation, and satisfiability testing.

Model generation-based approach:

1. Give a representation of the problem at hand.
2. Reach a solution by a model of the given representation.

3 Definitions and Methodology

3.1 Definitions

The definitions of *Cooperative Principle* by de *Conversational Implicature* are of Grice [11].

Formalizing the concept of Grice, we have:

Definition 4.1 $Says(X, Y, T|F)$ states that agent X asserts that predicate Y is either True (T) or False (F).

Stanford Encyclopedia of Philosophy [20] includes a formal definition of implicature, this and the natural language definition of omissive implicature, as well as our formal definition of omissive implicature, are found in [8].

What this definition encompasses is the possibility of drawing linguistic inferences from silence or omission, without interrupting the communicative interaction, given certain contexts.

In [5], we have defined our semantic rules for the five types of silence, namely:

1. Total Defensive Silence (TDS).
2. Partial Defensive Silence (PDS).
3. Acquiescent Silence (AS).

4. Prosocial^{+} Silence (Pro+).
5. Prosocial^{-} Silence (Pro–).

After the semantics of five types of silence were stated, we move to elaborate how to evaluate the consequences of silence in certain situations, allowing this to do implicatures.

Our definitions of intentional silence and unintentional silence for dialogic interactions can be found in [8].

3.2 Methodology

The methodology for the study of silence in the testimonies is illustrated in Fig. 2.

The methodology for the study of dialogues is detailed in Fig. 3.

CORPUS	SOURCE	CONTEXT Y PRECONDITIONS	PROCESS	KEY QUESTIONS
Logic puzzles The solutions to some of these problems could have practical repercussions	Specialized bibliography • Puzzles with testimonies • Source code	• Selection of puzzle • Formalization of testimonies and common sense rules • Problem solving with logic programming • Analysis and feedback	1. Silence type Selection 2. Omission modeling and its variants 3. Analysis and feedback	• All cases have a solution? • Are there models that contain the answer to the original problem? • What is the consequence of the silence appearing?

Fig. 2 Strategy for testimonies

CORPUS	SOURCE	CONTEXT Y PRECONDITIONS	PROCESS	EVALUATION
Dialogue games Rule-governed interactions between two or more players doing written statements	Software A text-adventures game or computer program that simulate a physical environment	• Source program & selection of dialogue • Maps, objetives and tasks • Formalization of statements • Programming	1. BEGIN dialogue 2. Interact 3. Restricted random insertion of an omission with its interpretation 4. Continue interaction 5. END dialogue	• Did not lose the sequence of the dialogue ? • Does the program solved the omission ? • Does the dialogue ended ? Metrics: Percentage of success

Fig. 3 Methodology for dialogues

4 Experimental Environments

The possibilities of interpreting natural language are very varied for each form of expression and this characteristic makes it difficult to formalize statements for their logical interpretation and analysis. But there is a shortcut, the puzzles, which, beyond a simple hobby, can lead us down interesting paths, accepting the challenge of one of its main promoters, Martin Gardner, who argued that no one can define exactly what words mean because there is no exact way to define something that is outside mathematics and logic [9]. The logical-linguistic puzzles allow to limit the use of natural language giving rise to logic. These puzzles facilitate the formalization of statements, in addition to the fact that their solution could have repercussions in practice or help in solving daily problems. Because of this, we use them as case studies to model omission in the testimonial context.

In all kinds of interviews, a dialogue is established and then, a role is played in turns exchanging statements, taking turns is used to order the movements in the games, to assign political positions, to regulate the traffic at intersections, to serve customers in commercial establishments and to speak in different situations (interviews, meetings, debates, ceremonies, conversations, and so on), these latter also referred as voice exchange systems. In these cases, the study of silence is important considering that it has meaning. In the field of social psychology, silence is a path that opens the distance in conversation. The source of information that silence represents may contain findings that help psychotherapist specialists to timely intervene risk situations in patients with some critical diagnoses such as depression. This is the context that is studied in dialogical interactions.

4.1 The Testimonials of Logical-Linguistic Puzzles

The possibilities of interpreting natural language are very varied for each form of expression and this characteristic makes it difficult to formalize statements for their logical interpretation and analysis.

The logical-linguistic puzzles, allow to limit the use of natural language giving rise to logic. These riddles facilitate the formalization of statements, in addition to the fact that their solution could have repercussions in practice or help in solving everyday problems.

To address the solution of the puzzle *The Criminal* [19], we have to think first of a form of representation of the problem that facilitates the analysis. In this case, the matrix representation (Fig. 4-i) is recommended to identify contradictory statements.

Whereas the statements of the suspects are:

Brown:

b_1 : *I didn't do it.* b_2 : *Jones didn't do it.*

Jones:

j_1 : *Brown didn't do it.* j_2 : *Smith did it.*

innocent	Brown	Jones	Smith
Brown	T	T	--
Jones	T	--	F
Smith	F	--	T

i. Testimonial SaysMatrix

	Brown	Jones	Smith
Brown	F	T	--
Jones	F	--	F
Smith	T	--	T

ii. Original puzzle solution

	Brown	Jones	Smith
Brown	T	T	--
Jones	T	--	T
Smith	F	--	F

iii. Natural puzzle solution

Fig. 4 Representation and solutions for puzzle The criminal

Smith:
s_1 : *Brown did it.* s_2 : *I didn't do it.*

We have that the pairs of contradictory statements are the following:

1. j_2 with s_2.

2. b_1 with s_1.

3. j_1 with s_1.

That is, such pairs of statements cannot be held true at the same time because an inconsistent system is reached. To find the solution, we have to analyze case by case, testing the possible assignments of certainty values. Several of them will lead to a contradiction, forcing to go back to find another possible assignment. This type of testing is known as trial and error. We can start in an orderly way by looking for that who tells two lies or two truths to see if all the certainty values are accommodated as required by the riddle. This is done using a possibility matrix associated with the testimonial matrix.

We will put the testimonies of those involved in a matrix with values of false (F) and true (T), using the innocence property instead of who did it, to differentiate what each one holds for himself and for others. We will use the predicate $says(r, innocent(c))$ whose meaning is that the person in line r declares the person in column c to be innocent or not.

The puzzle, *The Criminal* [19] allowing to study and explore the interpretations of silence (see Appendix 8). The analysis of this puzzle and the models generated for the TDS, PDS, and AS can be observed in [7]. Each type of silence has its implementation as metaprogramming in Python (see Appendix 9).

Figure 4-i includes the suspects testimonies expressed with the predicate $Says(x, innocent(y), T/F)$, defined above.

Figure 4-ii presents the solution for the original puzzle, found by trial and error, based on the preconditions of the original completion. As shown, the solution turns out that Brown is the culprit.

Other example is the puzzle *The Mystery* taken from [10]:

Vinny has been murdered, and Andy, Ben, and Cole are suspects.
Andy said: He did not do it. Ben was the victim's friend. Cole hated the victim.
Ben said: He was out of town the day of the murder. He didn't even know the guy.
Cole said: He is innocent. He saw Andy and Ben with the victim just before the murder.

Tables 1, 2 and 3 show some models where the presumed culprit of the crime depends on the type of silence interpreted (TDS, AS, or Pro+) and on who resorts to silence (Andy, Ben, or Cole) [5].

We have modeled and analyzed seven linguistic logic puzzles.

False Statements or Silence

We explored if there is a relation between silence and false statements, since this puzzle had that feature. As we revealed in Table 4, in the context of this case, additional information was hidden behind silence, opening more possibilities.

Table 1 Total Defensive Silence (TDS) models for the different agents

Silent agent(s)	Presumable culprit
{}	{ben}
{andy}	{ben, cole}
{ben}	{cole, andy, ben}
{cole}	{andy, ben}
{andy, ben}	{cole, ben, andy}
{ben, cole}	{cole, andy, ben}
{andy, cole}	{cole, ben, andy}
{andy, ben, cole}	{cole, ben, andy}

Table 2 Acquiescent Silence (AS) for the different agents

Silent agent(s)	Presumable culprit
{}	{ben}
{andy}	Unsatisfiable
{ben}	{ben}
{cole}	Unsatisfiable
{andy, ben}	{ben, andy}
{ben, cole}	{ben, cole}
{andy, cole}	{cole, andy}
{andy, ben, cole}	{cole, ben, andy}

Table 3 Analysis of Pro+ silence for different agents

Silent agent	Regarding	Presumable culprit
andy	ben	{cole}
andy	cole	{ben}
ben	andy	{cole, ben, andy}
ben	cole	{andy, ben, cole}
cole	andy	{ben}
cole	ben	{andy}

Table 4 Analysis of combined silence

#	TDS	PDS	Presumably culprit
1	Brown	j_1	{Smith, Jones}
2		j_2	{Smith, Jones}
3		s_1	{Smith, Jones}
4		s_2	{Smith, Jones}
5	Jones	s_1	{Smith, Brown}
6		s_2	{Smith, Brown}
7		b_1	{Smith, Brown}
8		b_2	{Smith, Brown}
9	Smith	b_1	{Smith}
10		b_2	{Smith, Jones}
11		j_1	{Smith, Brown}
12		j_2	{Smith}

4.2 Dialogical Interactions

In [8] we can find an application of the procedures (Figs. 5 and 6) that we proposed, that can be included in systems with dialogic interactions. In the same work, we reported the use of the prototype named Psychotherapeutic Virtual Couch (PVC) of which an interaction is included in Fig. 7 and an example of the records it generates in Fig. 8.

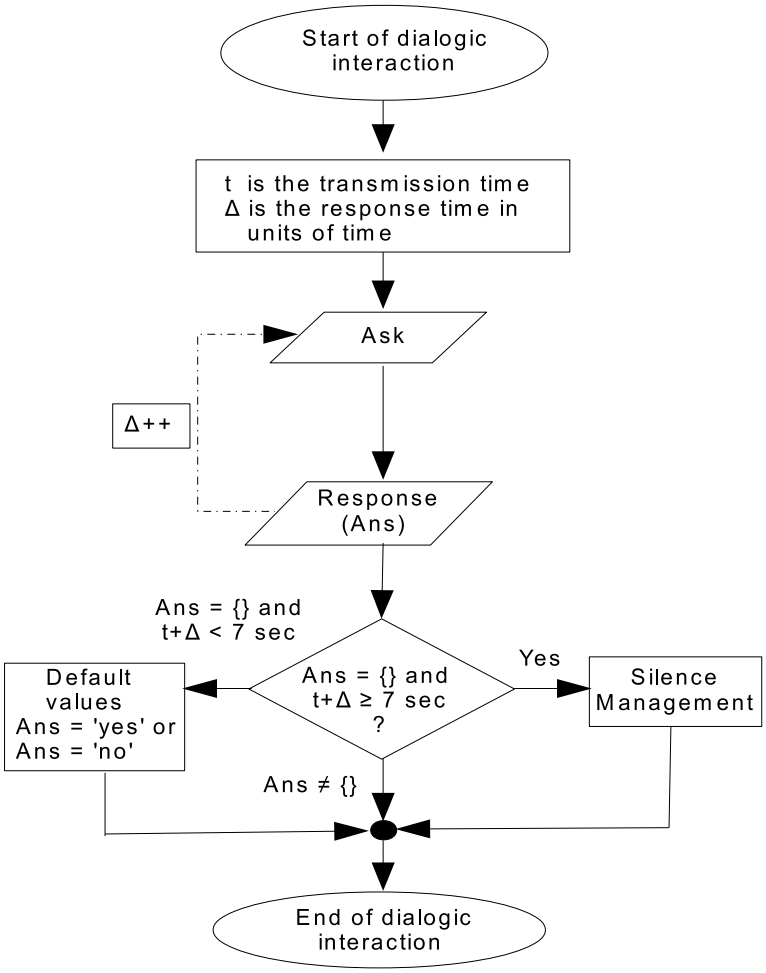
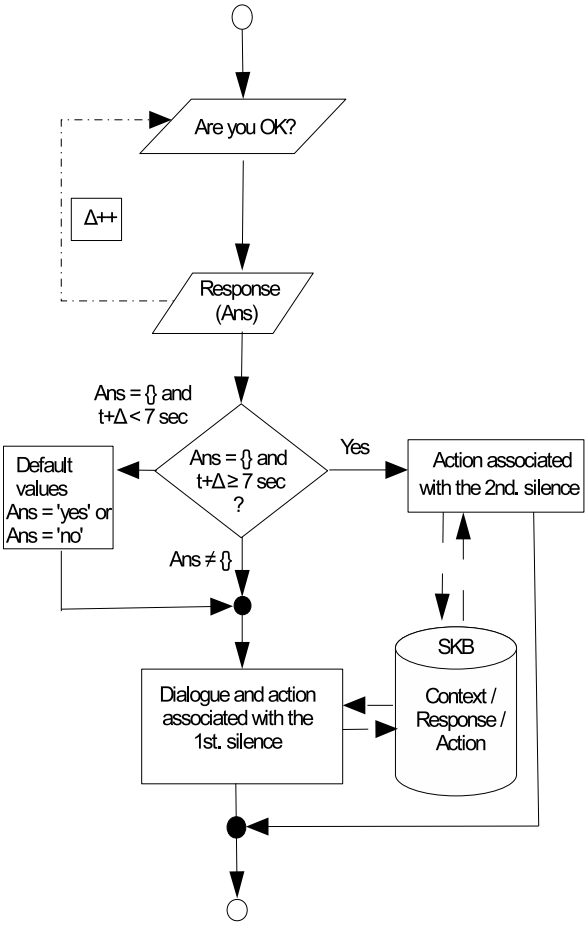


Fig. 5 Silence detection

Fig. 6 Silence management



5 Results

The testimonials of logical-linguistic puzzles.

Figure 9 shows a summary of puzzles and the properties that each one has with respect to the proposed semantics, as well as the behavior of its knowledge base.

Total Defensive Silence (TDS) in all cases always has a solution and shows that *silence protects those who use it* and provides logical support to the *right to remain silent*. Partial Defensive Silence (PDS), in the cases where it was used, allowed to test *the weight or importance* of each statement in the consequences of the testimony of a witness or agent.

```
You are visiting
The virtual psychotherapist couch!
************************************************
What is your nickname?: Cane
Welcome Cane !!!
How do you feel today?
Please choose a value
for each of the questions following:
Suicidal wishes (of 0 to 4):
Cane Are you OK? y/n:
Crying (of 0 to 4):1
Pessimism (of 0 to 4):2
Difficulty concentrating (of 0 to 4):1
Self-criticism (of 0 to 4):2
Irritability (of 0 to 4):1
Indecision (of 0 to 4):2
Tiredness or fatigue (of 0 to 4):1
Loss of interest in sex (of 0 to 4):
Cane Are you OK? y/n:
Agitation (of 0 to 3):1
Loss of pleasure (of 0 to 4):1
Feelings of punishment (of 0 to 4):
Cane Are you OK? y/n: y
Loss of energy (of 0 to 4):
Cane Are you OK? y/n: n
Failure (of 0 to 4):
Disagreement with oneself (of 0 to 4):1
Sadness (of 0 to 4):2
Changes in appetite (of 0 to 4):1
Change in sleeping habits (of 0 to 4):2
Loss of interest (of 0 to 4):1
Feelings of guilt (of 0 to 4):
Cane Are you OK? y/n:
Devaluation (of 0 to 4):1

Depression Level Score:
<41 - Severe depression

Thanks Cane for your visit
```

Fig. 7 PVC prototype

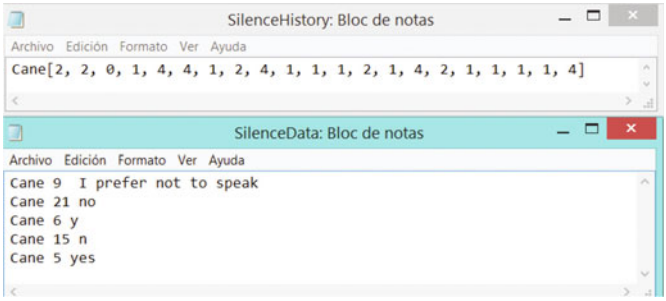


Fig. 8 Record of dialogic interaction of PVC

With condescending silence (SC), the last three puzzles show that solutions are not always found but where they are *the one who uses it is pointed out* confirming *he who is silent grants*.

The positive (Pro+) and negative (Pro-) pro-social silences tested in the last three riddles can be used in organizations and show that it is possible to induce decision-making, based on the support or detriment that can be given the silence of one person or agent with respect to another.

It is important to know what arguments or statements we can do without without altering the logical result of the interpretation. In two puzzles (Mystery and The

	Semantic rule for Silence					Equivalence		
Puzzle	Total Defensive	Partial Defensive	Condescending	Positive Pro Social	Negative Pro Social	Weak	Strong	Ratio: S,F
Shopping	●							
5 Discs	●							
Gentlemen	●							
Poisoned	●	●					●	●
Mystery	●	●	●	●	●	●		
Fraud	●	●	●	●	●		●	
Criminal	●	●	●	●	●	●		●

Fig. 9 Semantics and relationships of the case studies

criminal) we could see that it is possible to reduce the size of the knowledge base and obtain several models within which the solution to the problem is found, these two cases being examples of *Weak testimonial reduction* or *Weak equivalence*.

Two other puzzles (Poisoning and Fraud) allowed us to prove that, in some cases, by reducing the size of the knowledge base it is possible to obtain the unique solution, being an example of *Strong testimonial reduction* or *Strong equivalence*, proving this way the non-monotony property of the knowledge base and the obtaining of equivalent logic programs since we obtain the same answer set with them [15, 17]. With the *Strong testimonial reduction* the existence of superfluous statements in the testimonial context is verified, in other words, it is confirmed that, given two logic programs, where in one program some statements are silence (an agent is fully or partially muted), such program will be a reduction of the other. This is formally expressed in [8].

Finally, in two puzzles (Poisoning and The Criminal) it was possible to show that there is a relationship between silence and false statements.

Procedure Taking for granted that the testimonies of all people involved are already at hand, a strategy to analyze them can be (Fig. 10) as follows:

1. Determine agents and relations (predicates).
2. Express agent statements employing *Says()* predicate.
3. Supply definitions and common sense rules pertinent for the problem under consideration.
4. Recognize the different kinds of silence present in the problem.
5. Create a knowledge base to model the problem, considering the agent statements, common sense knowledge, and determined kinds of silence. According to the kind of silence displayed by agents, one or more of the programs modeling them,

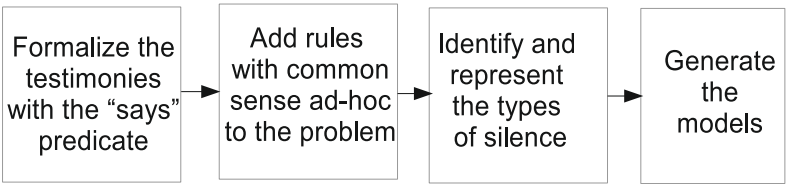


Fig. 10 A proposed strategy for testimony analysis

have to be applied, so that the corresponding agent affects the knowledge as a consequence:

```
t_def_silence (kb.pl, agent)
p_def_silence (kb.pl, agent, predicate)
acq_silence (kb.pl, agent)
```

6. Obtain the models with Answer Set Programming, considering the respective kinds of silence in the knowledge base:

```
clingo 0 kb.pl
```

7. Examine the scenarios obtained after the simulation.

The critical step in the proposed strategy is number 4. For instance, the obvious and common case is when one of the parties uses his/her right to keep quiet. So, we can proceed to contemplate the types of defensive and condescending silence, one by one, for that person. The cases that are not obvious but possible are the silences of the Pro-social type in defense of a guild or organization, although it is not obvious if there are elements to explore one or the other. For example, if through third parties it is known of a close friendship between some of those involved (Pro+) or of animosity or enmity between two (Pro-), where someone can remain silent. Nevertheless, some other situations can arise, for example, when two declarers A and B match individually in declarations p and q, but A also asserts r. This can lead to hypothesize condescending silence from B, or even a partial defensive silence, since r is being omitted. One can then proceed to represent and analyze the problem consequently.

Dialogical Interactions

For dialogic interactions between two human or non-human agents, we proposed to include a new dimension for silence, which can provide relevant information in some contexts, an example of which is in the area of psychology. In [8] we can find some possible lines of research.

6 Conclusions

During the development of the doctoral project, we were able to confirm that the intentional omission or silence in the communication process has not been sufficiently investigated. With the scrutiny and exploration in the scientific community of our area, we did not find evidence of the subject in Computational Sciences, therefore, the present work could be one of the first records related to the subject.

In the computational discipline, the closest thing to the occurrence of silence are the default values, i. e. those assigned "by omission" to some variables in interactive systems.

We have begun the study of areas of opportunity for the interpretation of the omission in each of the following aspects:

1. *The testimonial or logical-linguistic puzzles*. We were able to realize that natural language testimonial puzzles provide the opportunity to do qualitative research and produce logic-based knowledge representation models to analyze the consequences of omission in a linguistic setting. We show some important properties such as the equivalence of programs based on logic, reasoning on non-monotonic knowledge bases, and the relationship between omission and false statements.
2. *Dialogical interactions*. For experimental and quantitative research purposes, we show the use of a procedure for managing silence, generating records with information that can help decision-making. We formally define the omission implicature and the concept of dialogue that includes it as a possibility.

With the experiments carried out in the testimonial context, we were able to realize the power of omission, since its logical interpretation can point to any of the agents (human or not) involved in the process as the presumed culprit. In dialogical interactions, we find areas such as psychotherapy, where the timely interpretation of the information omitted in the interviews could save lives. Thus, we have confirmed the hypothesis:

The logical interpretation of the omission implicature contributes elements to the communicative process and helps decision-making.

Knowing the possible logical consequences of silence, you can resort to it, voluntarily, consciously, and with intention, according to the circumstances in which it occurs.

It is important to reflect on the power of silence, studied from a computational perspective, since by incorporating this dimension into interactive systems, relevant and vital information can be obtained in certain contexts.

Intentional silence or omission, intentionally interpreted, is contextual, clear, interactive, and completely concise.

Future Work

One of the short-term tasks is to put into practice the adoption or development of systems that include the interpretation of silence.

In the case of testimonies, some applications of the proposed semantics of silence can be applied in judicial proceedings, law, and police interviews [18] and probably

with them, models can be generated by using sensor technologies to detect silence [2]. According to our formal definition of omissive implicature and according to the context, predictions can be made to know what could be hidden (p) behind the silence, asking the question: What or who could p be? The solution could be part of a Base of Assertions or terms in the style of the Herbrand Base.

In the case of dialogues, the proposed methodology could be useful in psychotherapeutic consultations [12], for example, it could prevent depression from putting people's integrity at risk by making timely detection of the state of mood or degree of depression [1].

Some possible lines of research (threads) that could be developed are:

1. Design and solution of testimonial puzzles with various logic programming paradigms. Solving puzzles can have practical implications for doing everyday tasks.
2. Definition of agents that perform omissive implicatures in dialogical interactions. Agents who extend their intelligence with the interpretation of intentional silence.
3. The semantics of the omission used in testimonials and the components used in dialogues could have application in the theory of argumentation with logical programming and negation by failure [14].
4. Development of a theory or axiomatization of the omission implicature. Formally define linguistic inferences for omission conversational implicatures.

7 Derived Publications

During the development of the doctoral program, advances were presented in various forums and the following publications were reported:

1. A semantics of intentional silence in omissive implicature, Garcés-Báez, Alfonso, López-López, Aurelio, Journal of Intelligent & Fuzzy Systems, vol. 39, no. 2, pp. 2115-2126, 2020, DOI: 10.3233/JIFS-179877, Q3 JCR 2018, Q2 Engineering SJR 2019 [5].

2. Towards a Semantic of Intentional Silence in Omissive Implicature. Garcés-Báez, Alfonso, and Aurelio López-López. Digitale Welt 4.1 (2020): 67-73. Springer. https://doi.org/10.1007/s42354-019-0237-0 [6]

3. First Approach to Semantics of Silence in Testimonies. Garcés-Báez, Alfonso, López-López, Aurelio (2019). International Conference of the Italian Association for Artificial Intelligence, LNAI 11946. Springer, págs. 73-86. https://doi.org/10.1007/978-3-030-35166-3 [3]

4. Reasoning in the Presence of Silence in Testimonies: A Logical Approach. Garcés-Báez A., López-López A. (2021) In: Arai K. (eds) Intelligent Computing. Lecture Notes in Networks and Systems, vol 284. Springer, Cham. págs. 952-966. https://doi.org/10.1007/978-3-030-80126-7 [7].

5. A Logical Interpretation of Silence. Alfonso Garcés Báez, Aurelio López López. Computación y Sistemas, 2020, vol. 24, no 2. pp. 613-623. https://doi.org/10.13053/CyS-24-2-3396 [4].

6. Chapter 5. Pandemic, depression and silence. Garcés-Báez A., López-López A., Moreno-Fernández Ma. Del Rosario & Eva Mora-Colorado, in Women in science: academic and research experiences in upper secondary and higher education during the state of the pandemic, Carmen Cerón Garnica, Coordinator and Compiler of Work, Universidad Tecnocientífica del Pacífico S.C. 2021, pp. 80-100, ISBN 978-607-8759-19-4.

7. Silence in Dialogue: A Proposal and Prototype for Psychotherapy. Alfonso Garcés Báez, Alfonso, López-López A. (2022) In: Science and Information Conference. Springer., págs. 266–277 [8].

8 Code for Criminal Puzzle (Clingo 4.5.4)

```
%% Puzzle 51 of Wylie [19]
%% for the natural solution.
%%
suspect(brown;jones;smith).
%
%% Brown says:
says(brown,innocent(brown),1).
says(brown,innocent(jones),1).
%
%% Jones says:
says(jones,innocent(brown),1).
says(jones,innocent(smith),0).
%
%% Smith says:
says(smith,innocent(smith),1).
says(smith,innocent(brown),0).
%%%%%%%%%%%%%%%%%%%%%%
%
%% Everyone, except possibly for the criminal, is telling the truth:
holds(S) :- says(P,S,1),
            -holds(criminal(P)).
-holds(S) :- says(P,S,0),
             -holds(criminal(P)).
%
%% Normally, people aren't criminals:
```

```
-holds(criminal(P)) :- suspect(P), not holds(criminal(P)).
%
%% Criminals are not innocent:
:- holds(innocent(P)),holds(criminal(P).
%
%% For display:
criminal(P) :- holds(criminal(P)).
%
%% The criminal is either Brown, Jones or Smith, (exclusively):
holds(criminal(brown)) | holds(criminal(jones)) | holds(criminal(smith)).
#show criminal/1.
```

9 Prototype for Program Update in Logic (Python 3.7)

```
# Definition of Total Defensive Silence
# Input: knowledge base or logic program, and agent to silence
# Output: new knowledge base or logic program named 'kb'-'tds'-'agent'.lp
def t_def_silence(kb,agent):
   f=open(kb,'r')
   g=open(kb[0:len(kb)-3]+'-'+'tds-'+agent+'.lp','w')
   for line in f:
      if 'says('+agent == line[0:5+len(agent)]:
         line='%'+line
      g.write(str(line))
   f.close()
   g.close()

# Definition of Partial Defensive Silence
# Input: knowledge base or logic program,  agent, and predicate to silence
# Output: new knowledge base or logic program named 'kb'-'pds'-'agent'-'predicate'.lp
def p_def_silence(kb,agent,predicate):
   f=open(kb,'r')
   g=open(kb[0:len(kb)-3]+'-'+'pds-'+agent+'-'+predicate+'.lp','w')
   for line in f:
      if 'says('+agent+','+predicate+'(' == line[0:5+len(agent)+len(predicate)+2]:
         line='%'+line
      g.write(str(line))
   f.close()
   g.close()

# Definition of Acquiescent Silence
# Input: knowledge base or logic program, and agent to silence
# Output: new knowledge base or logic program named 'kb'-'as'-'agent'.lp
def acq_silence(kb,agent):
   f=open(kb,'r')
   g=open(kb[0:len(kb)-3]+'-'+'as-'+agent+'.lp','w')
   for line in f:
      if 'says('+agent == line[0:5+len(agent)]:
         line='%'+line
      elif 'says(' == line[0:5]:
         i=line.index(',')
         line_new='says('+agent+line[i:len(line)]
         g.write(str(line_new))
      g.write(str(line))
   f.close()
   g.close()
```

References

1. Beck, J.S., Beck, A.T.: Cognitive Therapy: Basics and Beyond. No. Sirsi) i9780898628470. Guilford Press, New York (1995)
2. Gaddy, D., Klein, D.: Digital voicing of silent speech (2020). arXiv preprint arXiv:2010.02960
3. Garcés-Báez, A., López-López, A.: First approach to semantics of silence in testimonies. In: International Conference of the Italian Association for Artificial Intelligence, LNAI 11946. pp. 73–86. Springer (2019). https://doi.org/10.1007/978-3-030-35166-3_6
4. Garcés Báez, A., López López, A.: A logical interpretation of silence. Computación y Sistemas **24**(2) (2020)
5. Garcés-Báez, A., López-López, A.: A semantics of intentional silence in omissive implicature. J. Intell. Fuzzy Syst. **39**(2), 2115–2126 (2020). https://doi.org/10.3233/JIFS-179877
6. Garcés-Báez, A., López-López, A.: Towards a semantic of intentional silence in omissive implicature. Digitale Welt **4**(1), 67–73 (2020). https://doi.org/10.1007/s42354-019-0237-0
7. Garcés-Báez, A., López-López, A.: Reasoning in the presence of silence in testimonies: a logical approach. In: Intelligent Computing, pp. 952–966. Springer (2021). https://doi.org/10.1007/978-3-030-80126-7_67
8. Garcés-Báez, A., López-López, A.: Silence in dialogue: A proposal and prototype for psychotherapy. In: Science and Information Conference, pp. 266–277. Springer (2022)
9. Gardner, M.: Science, Good, Bad, and Bogus. Prometheus Books (1981)
10. Gelfond, M., Kahl, Y.: Knowledge Representation, Reasoning, and the Design of Intelligent Agents: The Answer-set Programming Approach. Cambridge University Press (2014)
11. Grice, H.P.: Logic and conversation. Syntax Semant.: Speech Acts, Cole et al. **3**, 41–58 (1975)
12. Levitt, H.M.: Sounds of silence in psychotherapy: the categorization of clients' pauses. Psychother. Res. **11**(3), 295–309 (2001)
13. Lifschitz, V.: What is answer set programming?. In: AAAI. vol. 8, pp. 1594–1597 (2008)
14. Nieves, J.C., Osorio, M., Zepeda, C.: A schema for generating relevant logic programming semantics and its applications in argumentation theory. Fund. Inform. **106**(2–4), 295–319 (2011)
15. Osorio, M., Navarro, J.A., Arrazola, J.: Equivalence in answer set programming. In: International Workshop on Logic-Based Program Synthesis and Transformation, pp. 57–75. Springer (2001)
16. Revueltas, J.: Los días terrenales, vol. 15. Editorial Universidad de Costa Rica (1996)
17. Van Harmelen, F., Lifschitz, V., Porter, B.: Handbook of Knowledge Representation. Elsevier (2008)
18. Walton, D.: Witness Testimony Evidence: Argumentation, Artificial Intelligence, and Law. Cambridge University Press (2008)
19. Wylie, C.R.: 101 Puzzles in Thought and Logic, vol. 367. Courier Corporation (1957)
20. Zalta, E.N., Nodelman, U., Allen, C., Perry, J.: Stanford Encyclopedia of Philosophy (2003)