# Towards A Formal Semantics of Silence: An Analysis Based on the KoS Framework

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## Abstract

Despite its nonnegligible communicative role in verbal communication, conversational silence has been outside the concern of formal and computational semantics because of the difficulty of analysis arising from its extreme multimodal context-dependency in detection and interpretation. However, I argue that, whereas the conventional formal semantic theories whose level of analysis is a sentence or truth-conditional/situational worlds do not provide the tool to grasp the denotation of silence, KoS, a multimodal conversation-level semantic framework can successfully handle it. In this paper, I focus on turn and inter-turn silence in Levinson's classification of silence (turn, inter-turn, intra-turn), further subclassify those two classes of silence into inability, refusal, acceptance, turn-passing, truthfulness, unwillingness, and awkwardness silence by their forms and meanings, and formally describe and analyze them by presenting the lexical entries and the conversation rules with the perspective and the notation of KoS. I believe that this analysis can facilitate further research of silence in theoretical, experimental, and computational manners by explicitly expressing the grammar and the semantic content of silence and also demonstrate the possibility of the semantic annotation of silence in dialogue corpora.

## 1 Introduction

Silence often conveys meaning in verbal communication. This type of silence is called 'conversational silence.' Consider (2) from Wang (2019). ('X +> Y' expresses that conversational implicatures trigger an inference from X to Y.)

(1) (A conversation between two passengers on the street)

Man: Excuse me Ma'am where is the No.67 bus stop?

Woman: [silence; having heard the man's question]

Man: [take a closer look at the woman] Sorry, miss, could you please tell me what the No.67 bus stop is?

Woman: Go straight ahead, and turn right at the next crossroad.

+> The woman did not want to answer because she was unhappy with being called 'miss.'

The woman's silence takes a 'turn' in conversation, performs an illocutionary act, and generates some conversational implicature.[1] Also, silence is often described as 'ambiguous' (Perniola, 2010; Ferguson, 2003; Glenn, 2004; Jaworski, 2011). These two observations imply that conversational silence is a semiotic object with semantic content that should be disambiguated and semantically parsed to be understood by the dialogue participants. By developing formal descriptions, we can systematically and explicitly study the meaning of silence, facilitating theoretical, experimental, and computational research and analysis of what silence means and how humans understand it. It will also allow semantic annotations to silence in conversation corpora.

However, to the best of our knowledge, no formal semantic analyses have been given to silence. This is because the conventional formal semantics, which is only concerned with proposition- or world-level semantic phenomena in a single modality (speech or text), has no or little space for silence. Silence is one of the most extreme cases of multimodal communication. Since it is (a subclass of)

[1] There can be diverse approaches to the nature of silence's semantic contents and the inference derived from them. For example, the inferences required to interpret conversational silence can be analyzed as cases of conversational implicature, explicature, impliciture, or something else depending on the theory. However, the detailed discussion of the nature of those inferences is beyond the scope of this article and I set the semantic contents of silence as simple as possible and all the relevant inferences as conversational implicature here.

the absence of utterances or any signs, one cannot grasp it based on the connection between the signified and the overt signifiers cohering in any single modality, and all of the surrounding contexts are needed to detect its presence and interpret its meaning. Meanwhile, the KoS framework provides a way to define formal structures and conversational rules for multimodal communication by encoding any information about the environmental or social/discursive situations surrounding the participants. Thus, the natural next step is to use the framework to analyze the pragmatic mechanism surrounding silence.

In this paper, I classified and analyzed the form and the content of silence using KoS by formulating the lexical entries and the conversational rules that explain the semiosis of silence with some dialogue examples. Section 2 briefly reviews the previous studies and concepts on silence relevant to this paper, the TTR/KoS framework, which is the theoretical tool to analyze silence in this paper, and the other exemplary studies of multimodal and/or paralinguistic signs using the framework. The scope of analysis of this paper is formulated more in detail with the concepts reviewed in Section 3. Sections 4 and 5 classify and analyze the sub-classes of turn silence and inter-turn silence respectively.

## 2 Background

### 2.1 Previous studies on silence

Several scholars in the field of linguistics classified and analyzed silence as a linguistic object that has semantic and/or pragmatic functions. Levinson (1983) classified silence into three types based on the relation to conversation turns: intra-turn silence (*pause*), inter-turn silence (*gap* or *lapse*), and turn silence. Kurzon (1995) divided silence into two types (*intentional* and *unintentional*) and suggested the modal interpretation of silence, that silence can be interpreted as 'I cannot speak', 'I don't want to speak' or 'I must/may not speak.' Kurzon (2007) covers more diverse types of silence, giving four types of silence: conversational, thematic (avoiding talking about a specific topic while speaking), textual (silence when internally reading or reciting a particular text such as a prayer), and situational (silence required by sociocultural norms in specific spacetime). Ephratt (2007) distinguished *eloquent silence*, which has an active semantic content on its own, from *stillness* (e.g. just listening or in the library), *pause*, and *silencing* (prohibition to speak) and Ephratt (2008) analyzed the role of eloquent silence in terms of the six functions of language in Roman Jakobson's communication model. Wang (2019) followed the classification of Levinson (1983)(turn silence, inter-turn silence, and intra-turn silence) and focused on analyzing turn silence using Relevance Theory, describing the interpretation of silence as establishing its relevance in the conversation by three types: addition of a new contextual implication, strengthening of previously held assumptions, and elimination of false assumptions.

### 2.2 TTR/KoS framework

The KoS framework, which is a theoretical framework of conversation-oriented semantics was proposed first in Ginzburg (1994), in which the structures of a shared 'dialogue gameboard' and an 'information state table' are defined and the effects and the meanings of an utterance are analyzed as the updates of the dialogue gameboard and the information state table according to the conversational rules. Later, this approach was reformalized with Type Theory with Records(Cooper and Ginzburg, 2015), which facilitated a richer representation concerning every level of language from phonetic and syntactic to semantic and pragmatic levels. TTR's versatility and flexibility allowed it to extend KoS's ability to the realm of multimodal face-to-face communication(Lücking and Ginzburg, 2020), in which the diverse types of information such as gestures, facial expressions, the context from visual situations are exchanged together with the linguistic signs and take place sequentially or simultaneously. The advantages of this approach toward multimodal communication and paralinguistic signs are well exemplified in the analysis of laughter by Ginzburg et al. (2020).

On the other hand, the interpretation of (para)linguistic signs such as silence seems to heavily rely on their relevance in a dialogue and common sense reasoning. Relevance in terms of the KoS framework was explored by Ginzburg (2010), and the mechanism of common sense reasoning was deeply analyzed with the KoS/TTR framework by Breitholtz (2020).

### 2.3 Why use KoS to analyze silence?

The denotation of silence is extremely difficult, if not impossible, to formulate in the conventional theories of formal and computational semantics.

The difficulties in the formal analysis of silence can be contemplated in three aspects: defining its 'phonetic' forms, its semantic contents, and the reasoning process behind the interpretation. Our view is that KoS (Ginzburg, 2008) is the framework that can provide a nice solution to the three problems.

Silence is difficult to define formally in terms of the 'phonetic' form. The forms of signs belonging to other classes of signs can be defined by the realization of specific patterns in certain modalities. For example, a class of speech utterances or laughs can be detected by certain patterns of the speaker's vocalization, and the act of nodding can be defined by the specific type of head movements. However, that is impossible for silence. One might be tempted to do that, but if they try to define the form of silence as the simple absence of speech for some time duration, they will get into two types of trouble immediately. First, nonverbal expressions such as head movements or gestures often replace the role of speech, and it seems inappropriate to say that silence is realized as an independent type of expression in those cases. Second, the conversational context is necessary to detect conversational silence. For example, silence has an expressive meaning when it is followed by a question to the silent person. In contrast, it seems inadequate to regard the unmarked stillness in non-conversational contexts (e.g. reading in a library) or the silence of the truthful listeners in the same light. The meaning implied by silence can be distinguished depending on the dialogical contexts such as the questions under discussion, the expected next move, or the common ground. Fortunately, the KoS framework provides a way to include the multimodal dimensions and the dialogue context in the definitions of various types of silence.

There are also numerous examples of silence whose semantic contents are difficult to analyze within the perspective of classical formal semantics in which units of analysis are propositions/sentences or worlds. Silence is interpreted as a sign of seriousness and truthfulness in some cultures while it means disengagement in the conversation or the negation of the following statement in other cultures. To formalize the semantic contents of these examples of silence, one should utilize a semantic theory on the conversation level. The KoS framework, which was born as a conversation-oriented semantic theory from the beginning, can handle them systematically by treating the contents and the effects of silence from the perspective of updating the 'dialogue gameboard.'

Lastly, the complex reasoning process that critically affects the interpretation of silence is another key obstacle to the formal understanding of silence. Consider (1) from Wang (2019). To interpret and respond correctly to the woman's silence, one has to derive the conversational implicature using background knowledge and multimodal situational information together. While the theoretical ideas in formal pragmatics such as Gricean theories or Relevance Theory in pragmatics give us a great insight into the principle of the reasoning behind conversational implicature, they do not provide the formal and explicit explanation of the reasoning mechanism at least at the level to which the KoS framework aims to attain. On the other hand, the KoS framework includes the development of the formalization of common sense reasoning during dialogues using concepts such as *enthymemes* and *topoi* (Breitholtz, 2020). Moreover, I expect that this theory of dialogue reasoning can be easily combined with the formal semantics of multimodal communication, which is also provided by the framework (Lücking and Ginzburg, 2020), and this connection is necessary to explain phenomena like (1), which is difficult to handle for most of the previous approaches in formal pragmatics. Although I will not cover the theoretical accounts for common sense reasoning during dialogues in this paper, the likelihood of productive future research strengthens our motivation to work in this direction.

## 3 The scope of analysis

From Kurzon (2007)'s four classes of silence, I will focus on conversational silence. Textual and situational silence have relatively minor importance in linguistic accounts of silence because they play no roles in verbal communication and they seem to be outside of the realm of dialogues generally. Even when they take part in the situational environments of conversations in some cases (for instance, a prayer interrupting a conversation and referred to by the participants afterward), the update mechanism of dialogue gameboard seems to be unclear and much harder to grasp at least in the current KoS framework. I also excluded thematic silence from our scope because it is not a prototypical case of silence where speech is not being produced. Although I anticipate that they may be analyzed in a similar manner to this paper in the future. they

require another paper to be properly covered.

There are some problems to be resolved in setting the definition and the scope of analysis for conversational analysis as well. There may be several different notions of silence that may produce confusion. For example, nodding, head-shaking, or pointing one's finger without speaking can constitute a sufficient answer to a question in many cases. The basic intuition here is that they should not be considered as the most basic cases of conversational silence despite the lack of speech because they convey the messages in non-phonetic *tiers* and therefore it is the nodding, the head-shaking, and the gestures, rather than silence, that convey the messages. I will call this notion of silence "conversational silence in the narrow sense," which requires no locutionary acts to be produced in any modalities. On the other hand, there is plenty of academic literature on silence in which silence is treated as something that can be combined with facial expressions or gestures. I will call their notion of silence "conversational silence in the broad sense," which requires only the vocal tiers to be empty. There seems to be a considerable range of phenomena where conversational silence and signals in non-verbal tiers interact to produce an additional meaning that cannot be explicated by silence or non-verbal signals alone and the broader notion of conversational silence is required. Nevertheless, I leave this for future research and will simply focus on the explication of the purer forms of silence by setting silence's 'phonetic' events as the absence of any markedly active 'phonetic' signals in all of the *tiers* in a dialogue here.

Among Levinson (1983)'s three classes of conversational silence(turn, inter-turn, intra-turn), I focus on turn and inter-turn silence. Pause (intra-turn silence) is excluded from our study because it is affected by diverse variables, including processing difficulties (Goldman-Eisler, 1958), breathing (Werner, 2023), and prosodic planning (Krivokapić, 2007), which make it an incomparably harder subject for formal linguistic description.

## 4 Turn silence

Turn silence is a type of conversational silence realized when a participant produces no overt signals while being expected to say something in their given turn. In conversational analysis, the expectations that create the condition of turn silence are explained in terms of a 'turn-taking' system and

$$\begin{bmatrix} \text{preconds} : \begin{bmatrix} \text{spkr} & : \text{Ind} \\ \text{addr} & : \text{Ind} \\ \text{P1} & : \text{IllocRel} \\ \text{LatestMove} & \\ = \text{P1(spkr,addr)} & : \text{IllocProp} \\ \text{qud} & : \text{poset(Ques)} \\ \text{facts} & : \text{set(Prop)} \end{bmatrix} \\ \text{effects} : \begin{bmatrix} \text{spkr} = \text{preconds.addr} \\ \text{addr} = \text{preconds.spkr} \\ \text{P2} : \text{IllocRel} \\ c_1 : \text{AdjPair(P1,P2)} \\ \text{Moves} \\ = [\text{P2(spkr,addr)}| \\ \quad \text{preconds.Moves}] \\ \quad : \text{list(IllocProc)} \\ \text{qud} = \text{preconds.qud} \\ \quad : \text{poset(ques)} \\ \text{facts} = \text{preconds.facts} \\ \quad : \text{set(Prop)} \end{bmatrix} \end{bmatrix}$$

Figure 1: 2-PTEP

adjacency pairs. For example, a question from the current speaker is supposed to be followed by the answer from the current listener, a statement or a request by its acceptance (or rejection), a greeting by the counter-greeting, a calling by a response, or a complaint by the excuse or remedy. These sequentially and functionally related pairs of speech acts are called *adjacency pairs*. The turn exchange that takes place is processed by a conversational rule called 2-PTEP (Ginzburg, 2008), which is described in Figure 1. [2]

Propositional or illocutionary contents are given to turn silence. I argue that this is an adequate treatment considering several examples. (1) and (2) demonstrate that turn silence can generate conversational implicature, and conversational implicature is evidence of the existence of propositional contents (or *what is said*) because a conversational implicature occurs based on the meaning of *what is said* or the literal semantic contents (Harnish et al.,

[2]There might arise a question of whether it is appropriate to assign the role of *spkr* to the silent actor when *spkr*'s phonation is empty or not, considering *spkr* in the narrower sense is defined as the one who produces verbal signals on the speech tier(Lücking and Ginzburg, 2020, p. 10). However, *spkr* without that narrower restriction is just an object typed as Ind and seems to be correctly handled by the pre-existing conversational rules. Therefore, I avoided uneconomical decisions here.

1976, pp. 339–341; Levinson, 1983, p. 113; Wilson and Sperber, 1981, p. 160). (3) and (4) provide examples where the propositional contents of turn silence are accepted and refuted respectively. (5) shows that silence can give rise to intended meaning clarification requests.

(2) A: Come on! I know that you are more generous than this.

B: [silence]

A: I'm just kidding.

+> B did not want to respond because A said something inappropriate.

(3) A: Am I disturbing you?

B: [silence]

A: Okay.

(4) A: Is it you who broke the coffee machine?

B: [silence]

A: No, I won't let you reimburse me for that. Just tell me frankly.

(5) A: Did you watch the last episode of [TV series]? It was better than I expected!

B: [silence]

A: Why are you saying nothing? Were you disappointed as a fan of the series?

I adopted a simplified version of Kurzon (1995)'s modal interpretation of silence, accepting the silence of "I can't speak" and the silence of "I do not want to speak," and discarding others. Acceptance silence was newly added as a distinct class of turn silence, which is outside of Kurzon (1995)'s modal interpretation and is strongly motivated by the dialogue structure of the KoS framework. Turn-passing silence that occurs in group conversations is discussed after the other types of turn silence.

### 4.1 Inability silence

A participant who is supposed to speak in a given turn sometimes fails to speak due to being unable to speak something at the very moment. This type of silence, which is caused by the participant's inability to speak, is called *inability silence*. Because it is not an intentional sign, it is inappropriate to explain its signification by a lexical item for it. Unlike refusal silence, there is no locutionary act because the silent person has no choice and no *moves* are added. Instead, the silent person's inability to express themself is discovered or inferred by other

$$
\begin{bmatrix}
\text{tcs} & : \begin{bmatrix} \text{dgb} & : \text{DGBType} \\ \text{private} & : \text{Private} \end{bmatrix} \\
\text{B} & = \text{dbg.spkr} : \text{Ind} \\
\text{B.preconds} & : \begin{bmatrix}
\text{spkr} & : \text{Ind} \\
\text{addr} & : \text{Ind} \\
\text{P1} & : \text{IllocRel} \\
\text{P2} & : \text{IllocRel} \\
\text{LatestMove} & : \text{P1(spkr, addr)} \\
c_1 & : \text{AdjPair(P1,P2)} \\
c_2 & : \begin{bmatrix} \text{addr.silence.length} \\ > \theta^l_{unable} \end{bmatrix}
\end{bmatrix} \\
\text{B.effects} & : \begin{bmatrix}
o & : \text{Ind} \\
c_3 & : \text{About}(o, \\
\text{AbleToRespond(addr)?)} & \\
\text{VisSit.InAttention} & \\
= o : \text{Ind} &
\end{bmatrix}
\end{bmatrix}
$$

Figure 2: CheckInability - The conversational rule to deal with inability silence

participants from the contexts. On the other hand, one normally tends to check whether there are abnormal symptoms indicating a person's inability to answer when the person is supposed to answer but showing no responses. This reaction pattern can be expressed as a conversational rule, which can be roughly expressed as Figure 2.

$\theta^l_{unable}$ is the time threshold for the detection of inability silence, and if the time interval of silence is not sufficiently long, the conversational rule is not applied. In this paper, all types of silence have their own time thresholds, written as $\theta_{silence-type}$. $\theta^u_{silence-type}$ and $\theta^l_{silence-type}$ are the lower and the upper bound for the duration of silence, respectively.

### 4.2 Refusal silence

Refusal silence is a type of silence in which the silent agent expresses that they do not want to answer or express anything. Unlike inability silence, it generates illocutionary acts, updating the Moves in the dialogue gameboard. The lexical entry for refusal silence can be expressed as Figure 3.

Finding the reason why the silent person does not want to express anything is an important part of communication involving refusal silence. When it is failed, clarification requests on the intention can rise as (6). This is done by common sense reasoning, which is formulated using *enthymemes*

$$\begin{bmatrix} \text{s-event} : \begin{bmatrix} \text{phon} & : \text{SilencePhon} \\ \text{headMove} & : \text{NoHeadMove} \\ \text{gesture} & : \text{NoGesture} \\ \text{s-time} & : \text{TimeInt} \\ c_1 & : \text{s-time.length} > \theta^l_{refusal} \end{bmatrix} \\ \text{dbg-params} : \begin{bmatrix} \text{spkr} & : \text{Ind} \\ \text{addr} & : \text{Ind} \\ \text{P1} & : \text{IllocRel} \\ \text{P2} & : \text{IllocRel} \\ \text{p} & : \text{Prop} \\ \text{LatestMoves} & \\ = \text{P1(spkr, addr, p)} & \\ & : \text{IllocProp} \\ c_2 & : \text{AdjPair(P1,P2)} \\ \text{facts} & : \text{set(Prop)} \\ \text{f} & : \text{AbleToRespond(addr)} \\ c_3 & : \text{member(f, facts)} \\ \text{P-Reason} & : \text{Prop} \end{bmatrix} \\ \text{content} = \text{Assert(addr, spkr,} \\ \quad \neg \text{ WantToSpeak(addr, P-Reason))} \\ \quad : \text{IllocProp} \end{bmatrix}$$

Figure 3: The lexical entry for refusal silence

and *topoi* in the KoS framework. The detailed mechanism is beyond the scope of this paper, but let's analyze a situation as an example.

(6) A: Can you help me with my homework? It is super hard for me!

B: [silence]

A: Why aren't you answering? Are you still angry at me because I ate the last piece of the cookies?

B: Yes.

A: Come on. I'll buy new ones for you.

### 4.3 Acceptance silence

Acceptance silence is motivated by the following examples where the questions of $p$? are resolved by silence.

(7) A: Am I disturbing you?

B: [silence]

A: [silence]

(8) A: I will open the window because it's hot here.

B: [silence]

$$\begin{bmatrix} \text{s-event} : \begin{bmatrix} \text{phon} & : \text{SilencePhon} \\ \text{headMove} & : \text{NoHeadMove} \\ \text{gesture} & : \text{NoGesture} \\ \text{s-time} & : \text{TimeInt} \\ c_1 & : \text{s-time.length} > \theta^l_{accept} \end{bmatrix} \\ \text{dbg-params} : \begin{bmatrix} \text{spkr} & : \text{Ind} \\ \text{addr} & : \text{Ind} \\ \text{qud} & = [p?|\text{qud.tail}] \\ & : \text{poset(ques)} \\ \text{facts} & : \text{set(Prop)} \\ \text{f} & : \text{AbleToRespond(addr)} \\ c_2 & : \text{member(f, facts)} \end{bmatrix} \\ \text{content} = \text{Accept(addr, spkr, } p) : \text{IllocProp} \end{bmatrix}$$

Figure 4: The lexical entry for acceptance silence

A: [A opens the window]

In the KoS framework, an act of assertion 'Assert(spkr, addr, $p$)' adds $p$? to the qud and this question should be resolved by either an accepting $p$ or other $p$?-specific remarks, including the rebuttal of $p$. Therefore, if we assume that B's silence in (7) is an asserting move (refusal silence) in the dialogue, A's silence should be an accepting move towards B's silence. This gives us the motivation to distinguish these two types of silence: refusal silence and *acceptance silence*. B's silence in (8) shows that acceptance silence can be realized not only after another silence but also after an overt speech. The lexical entry for acceptance silence can be expressed as Figure 4.

## 5 Inter-turn silence (Gap)

Inter-turn silence is a subclass of silence that does not constitute an independent turn but takes place between other turns. Unlike turn silence, the semantic analysis of inter-turn silence cannot be analyzed as an independent speech act or move in a dialogue. Here, I suggest three examples of inter-turn silence: truthfulness silence, unwillingness silence, and awkward silence. This should not be considered to be a complete list of the sub-classes of inter-turn silence because the number of the classes may increase due to some possible discoveries in the future.

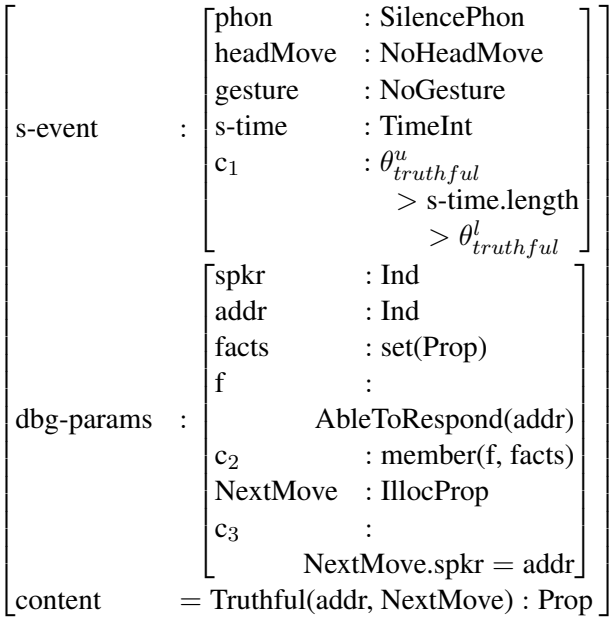


Figure 5: The lexical entry for truthfulness silence

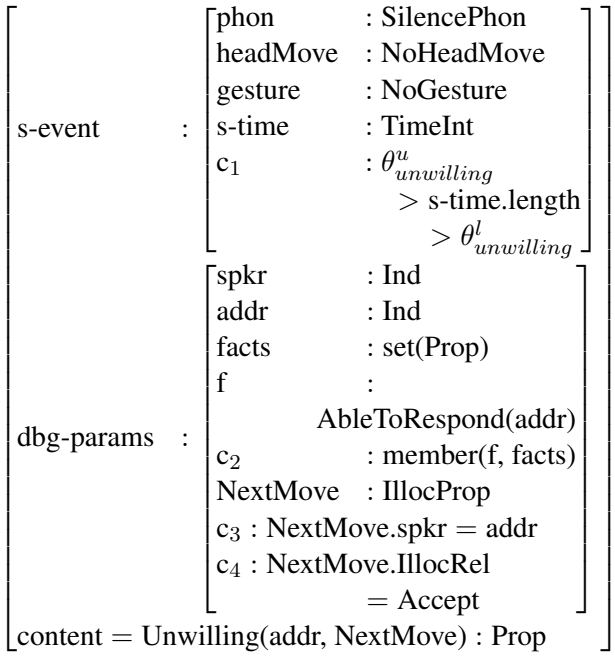


Figure 6: The lexical entry for unwillingness gap

### 5.1 Truthfulness silence

Literature on the silence culture has reported that silence conveys truthfulness in some cultures such as Japan(Lebra, 1987; Saville-Troike, 1985) and Jordan(İbrahim, 2013) while it is not the case in the English-speaking world and the Latin American culture, and this difference often produces intercultural miscommunication(Nitta, 1987; Nakane, 2007; Brannen, 1997). These examples of miscommunication give us the motivation to formulate this type of silence as a sign lexically encoded depending on the culture. For instance, American people's misunderstanding of Japanese people's silence can be explained by the lack of truthfulness silence in their lexicon, which results in interpreting them as an awkward silence or refusal silence. The following table is the lexical entry for the silence indicating truthfulness that takes place between turns. Unlike Refusal silence, its truthfulness is about the future move that will be performed by the currently silent person. For this reason, it is inherently inter-turn silence preparing for the following turn, and if the silent ends their turn only with silence (e.g. not answering the question at all), one of the lexical conditions ($c_3$) cannot be satisfied, and thus the silence is not interpreted as a sign of truthfulness anymore.

There should be some conversational rules for connecting truthfulness to the next move, and I expect the rules can be made in a similar manner to the conversational rules for finding the affiliates of co-speech gestures as suggested by Alahverdzhieva (2013) and Lücking and Ginzburg (2020). However, I will not cover a detailed analysis of them in this paper.

### 5.2 Unwillingness gap

Depending on the culture and the context, the silence before answers can indicate reluctance, unwillingness, half-heartedness, or even the negation of the subsequent answers. According to Wang (2019), "in Philippines when an electric appliance such as TV or water heater does not work and the owner calls an electrician, the electrician who keeps silent for a while on the phone and then promises to come will not come at all and the owner will just call another one." This is not true in many other cultures. The cultural difference surrounding this type of silence can be analyzed either by setting a distinct lexical item of silence for 'unwillingness gaps,' or by assigning a different set of topoi and enthymemes depending on the culture. Figure 6 is the lexical entry for unwillingness gap.

### 5.3 Awkward silence

Even when there are no questions under discussion and no responses anticipated, silence can create an uncomfortable mood if the conversation does not

$$\begin{bmatrix} \text{s-event} & : & \begin{bmatrix} \text{phon} & : \text{SilencePhon} \\ \text{headMove} & : \text{NoHeadMove} \\ \text{gesture} & : \text{NoGesture} \\ \text{s-time} & : \text{TimeInt} \\ c_1 & : \text{s-time.length} > \theta^{l}_{awkward} \end{bmatrix} \\ \text{dbg-params} & : & \begin{bmatrix} \text{participants} : \text{set(Ind)} \\ \text{qud} = \emptyset : \text{poset(Ques)} \\ \text{facts} : \text{set(Prop)} \\ \text{f} : \forall a \in \text{participants}.\ \text{AbleToSpeak(a)} \\ c_3 : \text{member(f, facts)} \end{bmatrix} \\ \text{content} = \text{Awkward(participants, } \delta) : \text{Prop} \end{bmatrix}$$

Figure 7: The lexical entry for awkward silence

$$\begin{bmatrix} \text{preconds} & : & \begin{bmatrix} \text{LatestMove} : \\ \text{Awkward(participants, } \delta) \end{bmatrix} \\ \text{effects} & : & \begin{bmatrix} \text{NegativePleasantnessIncr}(\delta, \epsilon) \\ \text{.effect} \\ \text{Mood.Power.arousal} = 0 \end{bmatrix} \end{bmatrix}$$

Figure 8: AwkwardnessIncr - The conversational rule for the increase of awkwardness

continue smoothly. I call this type of silence as *awkward silence*, which is lexically encoded as in Figure 7. The intensity of awkwardness, written as $\delta$, may be different by culture. Once an awkward silence is added to Moves, a conversational rule expressed in Figure 8, AwkwardnessIncr is applied. As a result, the pve (positive-value excitement) is reduced toward 0 and the nve (negative-value excitement) is increased toward $\delta$. The AwkardnessIncr utilizes NegativePleasantnessIncr formulated in Mazzocconi (2019) as in Figure 9.

## 6 Conclusion

In this paper, I analyzed the forms and meanings of various types of silence with the KoS framework. In the history of semantics, most of the formal analyses have been showing their weakness later and refuted or counterargued by other researchers. I do not expect our analyses suggested in this paper to be faultless or complete. However, I believe that building formal analyses strict enough that can be rebutted and improved is an essential part of scientific research and its progress. I anticipate

$$\begin{bmatrix} \text{preconds} & : & \begin{bmatrix} \text{LatestMove.cont} \\ : \text{IllocProp} \end{bmatrix} \\ \text{effects} & : & \begin{bmatrix} \text{Mood.pleasant.affect.nve} \\ = \epsilon(\text{preconds.Mood.} \\ \text{pleasant.affect.nve}) \\ +(1-\epsilon)\delta \\ : \text{Real} \\ \text{Mood.pleasant.affect.pve} \\ = \epsilon(\text{preconds.Mood.} \\ \text{pleasant.affect.pve}) \\ : \text{Real} \end{bmatrix} \end{bmatrix}$$

Figure 9: NegativePleasantnessIncr - The conversational rule for NegativePleasantnessIncr

that this direction of research can contribute to the scientific understanding of silence and intercultural differences in communication and the development of general-purpose dialogue systems that parse and understand human dialogues in the future.

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