AN INVESTIGATION OF INTERACTIONS WITH CONVERSATIONAL VIOLATIONS: INSIGHTS FROM VISUAL PERCEPTION AND GRICEAN MAXIM VIOLATIONS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF INFORMATICS OF
THE MIDDLE EAST TECHNICAL UNIVERSITY
BY

BENGISU ÇAĞILTAY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN
THE DEPARTMENT OF COGNITIVE SCIENCES

NOVEMBER 2020

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ABSTRACT

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November 2020, 53 pages

Linguistic principles at various levels are crucial in maintaining a reliable and transparent communication for dyadic interactions. However, violating these principles might result in unwieldy and problematic communications. Gaze can be a medium of reflecting the cognitive responses when conversational violations occur. An eye-tracking study was conducted to investigate visual patterns in communication in response to social communication errors, specifically Grice's Maxims violations. This study investigates how social-communicative errors affect task performance and gaze during social interaction. The results suggest participants' visual exploration patterns shift towards the violator speaker for the maxim of Relation violation, and the gaze stays mostly within the task area for the Quantity, Quality, and Manner violations. In addition, the response time increased for Quantity and Quality violations, followed by the Manner and Relation violations. Overall, this work ties visual cognition and linguistic principles for conversational Gricean Maxim violations in which the findings contribute to the design space in conversational agent interactions, particularly in human-computer interactions.

Keywords: visual cognition, pragmatics, eye-tracking, human-computer interaction

ÖZ

KONUŞMA İHLALLERİ BULUNDURAN ETKİLEŞİMLERİN GRİCE'IN NİYET-MERKEZLİ SEMANTİK BAKIŞ AÇISI BAĞLAMINDA GÖRSEL ALGI ARACILIĞIYLA INCELENMESİ

Çağıltay, Bengisu

Yüksek Lisans, Bilişsel Bilimler Bölümü

Tez Yöneticisi: Doç. Dr. Cengiz Acartürk

Kasım 2020, 53 sayfa

Çeşitli düzeylerde dilsel ilkeler, ikili etkileşimler için güvenilir ve şeffaf bir iletişimin korunmasında çok önemlidir. Ancak, bu ilkelerin ihlal edilmesi uygunsuz ve sorunlu bir iletişim ile sonuçlanabilir. Göz hareketleri konuşma ihlalleri meydana geldiğinde bilişsel tepkileri yansıtan bir araç olarak kullanılabilir. Bu bağlamda, Gricein niyet-merkezli semantik bakış açısı ihlallerinin bir sonucu olarak doğan sosyal iletişim hatalarını görsel algı aracılığıyla inceleyebilmek için bir göz izleme çalışması gerçekleştirilmiştir. Araştırma kapsamında sosyal-iletişimsel hataların ikili etkileşim sırasında katılımcıların görev performansını ve göz hareketlerini nasıl etkilediği incelenmektedir. Yapılan deneyler sonucunda çeşitli iletişim kurallarının ihlallerine dayalı olarak ortaya çıkan görsel keşif modelleri göz-takip sistemi aracılığıyla analiz edilmiştir. İncelemeler sonucunda, katılımcıların göz hareketlerinin Bağıntı Kuralı ihlali durumunda ihlali gerçekleştiren konuşmacıya doğru kaydığı; Nicelik, Nitelik ve Açıklık Kuralları ihlallerine ise göz hareketlerinin görev alanı içerisinde kaldığı görülmüştür. Bu sonuçlara ek olarak, iletişim kural ihlallerinin etkisiyle katılımcıların ortalama cevap verme süresindeki artış sırasıyla Nicelik, Nitelik, Açıklık ve Bağıntı kuralları ihlalinde gözlemlenmiştir. Sonuç olarak, bu araştırma dil bilimi alanında Gricein niyet-merkezli semantik bakış açısını görsel algı aracılığıyla incelemiş olup, çalışma bulgularıyla insan-bilgisayar etkileşiminde sosyal iletişim arayüzleri tasarımı alanına katkıda bulunmaktadır.

Anahtar Sözcükler: görsel algı, semantik, göz hareketleri takibi, insan bilgisayar etkileşimi

To My Family

ACKNOWLEDGMENTS

First of all, I would like to express my thanks to my supervisor Cengiz Acartürk for his support and guidance during my research.

Besides my supervisor, I would like to thank my parents Nergiz and Kürşat, and my brother Bilgehan for being there for me in every step during this pathway.

I would also like to thank all of my colleagues from the Cognitive Science department at METU, especially Faruk Büyüktekin and Gizem Özen, who supported me at every step of my work and made sure I had fun along the way. I would also like to thank Batıkan Özkan, Ozan Ödül and Tuba Hato for their help in data annotations.

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LIST OF ABBREVIATIONS

HCI	Human-Computer Interaction
HRI	Human-Robot Interaction
TA	Thematic Analysis
TIPI	Ten Item Personality Measure
TOI	Time of Interest
AOI	Area of Interest
ANOVA	Analysis of Variance

CHAPTER 1

INTRODUCTION

To maintain a well-functioning conversation in daily lives, humans intuitively adapt linguistic frameworks into conversations. By trial and error, we learn to use these linguistic attributes seamlessly and effortlessly during social development. However, people might unintentionally violate these linguistic frameworks in communications. This violation may affect interactions by causing dissatisfaction, confusion, or even failure in communication. In addition to verbal responses to these violations, people may also express non-verbal cues including body gestures, facial expressions, or gaze patterns. While body gestures and facial expressions can be interpreted in daily interactions, it is challenging to do so for gaze responses. Thus, exploring how these conversational violations influence gaze patterns may uncover many unknowns in this domain.

Similar to people, social robots may unintentionally violate linguistic frameworks within their communications. As these conversational agents become more prevalent in daily life settings, following a human-centered approach is beneficial to better design socially adept technologies. Many factors, such as discourse analysis, gaze modeling, and social norm violations, should be investigated in the design of conversational agents, such as speech interfaces or social robots. When analyzing discourse, machine learning, and neural network algorithms may help identify social norm violations (e.g., Zhao et al., 2016). For embodied social agents, previous work investigated modeling approaches for mutual gaze between humans and robots influenced by human-like gaze behavior or conversational roles (e.g., Jokinen, 2018; Admoni & Scassellati, 2017; Aydin et al., 2017; Mutlu et al., 2012; Broz et al., 2011). While designing collaborative social robots, natural interactions should also facilitate how social and cognitive responses are influenced by communicative violations. These violations might shape design approaches for gaze models through factors such as visual exploration patterns, fixation durations, and conversational agents' discourse.

Grice (1975) introduced a framework, the Cooperative Principle, for identifying conversational violations. This Gricean framework suggests a mutual expectation of contribution to the conversation between interlocutors. Grice categorizes four ways in which the conversational implicature can be identified (i.e., the maxims of quantity, quality, relation, manner). Follow-up studies offered insight on the pragmatics of Gricean Maxims and how they are applied to technology such as chatbots, voice interfaces, or social robots (Jacquet et al., 2019; Knepper et al., 2013; Briggs & Scheutz, 2012; En & Lan, 2011; Kleinke 2010; Saygin & Cicekli, 2002). Overall, neglecting these conversational principles in natural interactions might result in an impaired conversation, and it can also be perceived as a social norm violation.

1.1 Research Questions

This thesis aims to observe and address interlocutor's responses to a set of conversational violations during a cooperative task between two humans: an instructor and a user. The study is based on a communicative task environment that investigates the user's visual perception and task performance in response to conversational violations. In this thesis, users' gaze responses in the presence of conversational violations were evaluated by adapting an eye-tracking methodology, along with qualitative measures, including observational video analysis and semi-structured interviews. This thesis contributes to the HCI field by providing a human-centered design approach for technologies with social and conversational attributes.

This thesis investigates the following research questions:

1. How do conversational violations affect gaze patterns and visual exploration?

    1.1. Do the violations cause a shift of gaze out of the task area?

    1.2. Do personality traits affect visual exploration?

2. How do conversational violations influence task performance?

1.2 Hypotheses

This thesis mainly focuses on the Cooperative Principle as a framework to formalize the conversational violations referred to in this work. Specifically, the research approach utilizes and focuses on Grice's Maxims to address the research questions presented in this thesis. Below are the hypotheses developed based on the relevant work, which will be presented in Chapter 2.

H1: The maxim violations will impact gaze by increasing fixation duration.

H1.1 Maxim violations will influence the user’s gaze towards the violator.

H1.2 Participants with higher agreeableness will gaze at the violator more than participants with lower agreeableness scores.

H2: Maxim violations will affect task performance by increasing the time spent on completing a task.

1.3 Significance of the Study

The emergence of this work is based on the theoretical grounds mainly covered by visual cognition and linguistics. This thesis combines quantitative and qualitative analysis approaches to investigate how people respond to instructions that violate conversational principles in a task-based environment. However, this study's interdisciplinary nature highlights an opportunity for future work to reach beyond visual cognition and linguistics.

The main contribution of this work to the Cognitive Science domain is to explore the relationship between conversational violations and gaze patterns. The exploratory findings highlight the relationship between pragmatics and visual cognition. In addition, the contribution of this work to the HCI and HRI domain is a preliminary approach for implementing gaze responses to conversational violations for the design space of social robots and chatbot. The findings from this study can be extended to implement gaze models for robots with respect to conversational violations and investigate design implications for sociable robots.

Overall, the exploratory findings presented in this thesis highlight potential approaches where visual cognition and linguistics can be bridged over to the fields of HCI and HRI in future work.

1.4 Organization of the Thesis

This thesis consists of five chapters. The first chapter discusses a brief introduction of the background related to this thesis, a description of the motivating factors that were an inspiration to investigate this field of cognitive science, and an outline of the thesis.

The second chapter introduces the fundamental concepts of this thesis's background and the works related to the main aspects driving this study. The literature review and related works consist of a wide range of studies from an interdisciplinary perspective of cognitive

science, including linguistic and cognitive aspects of human interaction. Selected work includes studies related to the cooperative principle, human gaze, and visual cognition during conversational violations and the applications of gaze and conversational violations in HCI and HRI.

The third chapter consists of the methodology and study design. The study design includes a building task with verbal instructions conducted between the experimenter and the participant. The verbal instructions within the task occasionally included social conversation violations. During the study, the participant responses were recorded, and eye gaze was measured. The fourth chapter states the quantitative and qualitative results obtained from the study. Chapter five discusses the quantitative results obtained by the eye-tracking analysis, the participant response times and task performances, and the qualitative results that highlight the contrast in response types of participants to instructions, including conversational violations. The conclusions of this research study, the key findings of this thesis are also discussed in chapter five, along with the limitations and future work.

CHAPTER 2

LITERATURE REVIEW

The background of this thesis reflects on communication frameworks and visual cognition. As a review of the communication attributes investigated in this thesis, a background on the linguistic frameworks related to conversational implicature (i.e., Grice's Cooperative Principle and Neo-Gricean Pragmatics) is presented. The literature review and related work highlight important work focused on gaze research, conversational violations, and the application to the HCI and HRI domain.

2.1 Linguistic Frameworks

Grice introduced the Cooperative Principle suggesting linguistic guidance to support a productive and successful conversational contribution between participants. The four conversational maxims that Grice presented are explained as follows:

1. *Maxim of Quantity:* The quantity of the provided information should not be more than required.

2. *Maxim of Quality:* The provided information should be correct and evident.

3. *Maxim of Relation:* The provided information should be relevant.

4. *Maxim of Manner:* The provided information should be clear, non-ambiguous, brief, and orderly.

The framework resulting from these conversational principles has been applied to a range of research domains over time. Some studies investigated the daily life applicability of Grice's Maxims to humor, writings, conversations, and in technologies such as chatbots

or customer service agents (e.g., Jacquet et al., 2019; Kassel & Rohs, 2019; Xiao et al., 2019; Gnewuch et al., 2017; Kleinke 2010; White 2001; Attardo 1990). Other lines of work focus on the developmental aspects of the cooperative principle: which investigates the stage of development which children detect violations of Gricean maxims (e.g., Nordmeyer & Frank 2018; Gweon et al., 2018; Okanda et al., 2015; Siegal et al., 2009). Similar studies focus on understanding children's awareness of information quality, speaker preference, sensitivity, or understanding of the maxim violations (e.g., Antoniou & Taguchi, 2019; Gillis & Nilsen, 2013; Ferrier et al., 2010; Surian et al., 2010; Eskritt et al., 2008).

However, other scholarly perspectives oppose the conversational implicatures that Grice suggested, namely the "Neo-Gricean Pragmatics." In general, Neo-Gricean approaches advocate for reducing or refactoring Grice's conversational implicature maxims. Huang (2017) states that the Neo-Gricean approaches were constructed since some consider Grice's cooperative principle as "vague, superfluous, vacuous, unfounded, and even plain contradictory." Huang lists the three main trajectories related to the neo-Gricean pragmatics as the Hornian Model, the Levinsonian Model, and the Relevance Theory (Horn, 1984; Levinson, 1983; Wilson & Sperber 2002). The Hornian Model reduces the Gricean Maxims to two principles: Quantity (Q-principle) and Relation (R-principle), in which the R-principle subsumes Grice's maxim of Manner. In general, the Hornian Model suggests that addressees should have sufficient contribution and say as much as they can (Q-principle) while speakers have necessary contributions and should say no more than they must (R-principle). The Levinsonian Model, on the other hand, criticizes the reduction of the Hornian model and argues that the Q- and R-principles have inconsistencies. The Levinsonian model reduces Grice's Maxims to three principles as Quantity, Informativeness, and Manner principles. This model suggests that each principle has a speaker's maxim and recipient's corollary (Huang, 2017). Finally, Wilson and Sperber (2002) presented the Relevance Theory, which has a more robust reduction approach to the Gricean Maxims and reduces them to one principle – Relevance. The theory is divided into two approaches, the cognitive and the communicative principle of relation. In sum, Wilson and Sperber describe the cognitive principle as "human cognition tends to be geared to the maximization of relevance" and the communicative principle as "every ostensive stimulus conveys a presumption of its optimal relevance" (Wilson & Sperber, 2002).

Overall, the background on conversational implicatures is discussed with respect to the Gricean and Neo-Gricean pragmatics, which the Neo-Gricean approach is to reduce the cooperative principles in order to formalize lower-level details of pragmatics. However, this thesis utilizes the approach of Gricean Maxims to adapt a high-level overview and roadmap to categorize conversational violations to support the goal of designing socially adept human-robot interactions.

2.2 Gaze and Conversational Violations

Researchers have investigated the relationship between linguistic utterances and gaze in conversational settings. In their study, Hemforth et al. utilized eye-tracking to compare English, French, and German speakers' preferences by focusing on the linguistic attributes that include Gricean Maxim of Manner. (Hemforth et al., 2010). The participants matched sentences that violated the maxim of Manner with their corresponding visual representation, while the fixation patterns and preferences of participants were measured. The results suggest that English, French, and German speakers focused on different visual regions when they encountered sentences violating the maxim of Manner. Furthermore, in another eye-tracking study, Engelhardt et al. investigated whether participants were sensitive to the violations of Gricean maxim of Quantity (Engelhardt et al., 2006). The results suggest that the violation of the maxim of Quantity might have a moderate effect on communication success, such that people are sensitive to under-shared information but not to overshared information. When information is overshared, the eye movements may suggest a state of confusion of the participants. However, Davies & Katsos found that people are sensitive to both dimensions of the maxim of Quantity (Davies & Katsos, 2013). Similarly, a study utilizing cognitively inspired cooperative language tasks demonstrated that task performance improves when adhered to the cooperative principle (Vogel et al., 2013). Related work shows that the personalities of human partners in an interaction might influence gazing towards faces. By utilizing eye-tracking to investigate dyadic communications, Broz et al. reported that the personality dimension "agreeableness" is correlated with an increased gaze towards faces (Broz et al., 2012). In summary, gaze is a medium of reflecting the cognitive responses when conversational violations occur.

2.3 Applications in HCI and HRI

Gricean maxims are applied to conversational technologies such as chatbots, voice interfaces, and social robotics. A set of studies conducted by Jacquet et al. investigated the effect of Gricean maxim violations on the perception of a chatbot and task performance of participants (Jacquet et al., 2018/2019). The results show that Relation violation increases the response time of participants. In addition, their results also suggest that violating the maxim of Quality influences the perceived humanness of the interface, along with a decrease in the task performance of participants for the maxim of Quality and Quantity. Saygin & Cicekli investigated the relation between Gricean maxim violations and users' perception by assessing the conversational processes via the Turing Test (Saygin & Cicekli, 2002). Their results show that when computers violate Grice's maxims, they tend to fail the Turing Test.

The affordances for communication and conversational violations might be crucial for the design attributes of a social robot. In HRI, research also integrates the linguistic framework of Grice's Cooperative Principle in social robotics to support human-robot dyadic communications (Briggs & Scheutz, 2012; Knepper et al., 2013). One study by En & Lan suggested that utilizing the Gricean maxims within robotics dialogues could integrate politeness in human-robot interactions (En & Lan, 2011). Furthermore, to improve user experience in HRI, Hanafiah et al. used computer vision to investigate the influence of gaze, proximity, and deixis in response to the violation of Grice's maxim of Relation (Hanafiah et al., 2004). Their results suggest that when a speech interface is supported with visual cues from the participants (i.e., proximity, gaze, pointing, and manipulating), robots could manage the linguistic ambiguity caused by the occurrence of the maxim of Relation.

Overall, the related work in HCI and HRI has utilized linguistic frameworks as-is in the design process of communicative agents and social robots. However, for these linguistic frameworks, communication errors might occur by both humans and social agents during natural interactions. In such cases, the agents should identify the violations and adapt the interaction to maintain a more human-like design in social interactions. One approach to managing this interaction is by investigating human gaze in these circumstances. Robot gaze patterns have been implemented in previous work, such that Mutlu et al. implemented human-like gaze for a robot based on conversational roles, i.e., addressee or bystander (Mutlu et al., 2012). Broz et al. modeled gaze behavior for a robot based on human pairs' eye-tracking data in a conversational setting (Broz et al., 2011). However, these conversational settings do not cover possible conversational violations and how this might influence gaze patterns. Thus, understanding how gaze plays a role in dyadic interactions that contain conversational violations and modeling human-like gaze in response to these violations requires further investigation.

2.4 Flexibility and Subjectivity of the Interpretation of Communication

Communication frameworks discussed in sections 2.1 and 2.2 focused primarily on literal information transfer, which does not include subjective interpretations of communication and conversational principles. However, people may also transfer information via different modalities, such as in non-verbal communication. Non-verbal transfer of information can lead to flexibility in people's perception of communicative principles due to subjective interpretation; for example, it can be perceived as being "deceptive" (e.g., Zuckerman et al., 1981; Edwards, 1997; Buller & Burgoon, 1996). Martin and Rubin (1994) found that communication flexibility can be related to social desirability, communication adaptability, and behavioral flexibility, but not related to rhetorical sensitivity. Additionally, the flexibility of communication can be influential in the interpretation of conversational violations. This flexibility may cause people to perceive

conversational violations differently based on their culture, language, the content of the communication, and the neurodiversity of people involved within the communication (e.g., Bilmes, 1993; Danziger, 2010; Dewaele, 2001; Surian L., 1996).

As an example of how culture may lead to flexibility in perceived conversational violations, a study by Lorrita et al. (1999) investigated which conversational violations were perceived as "deceptive" in Hong Kong Chinese culture. The investigation replicated a study from McCornack et al. (1992) conducted with Americans to test the differences in the cultural perception of conversational violations. The study of McCornack et al. was based on the Information Manipulation Theory, which described "deception" as an appeared result to the violations of any Gricean maxims. The results showed that Hong Kong Chinese participants experienced deception from Grice's maxim violations differently, compared to U.S. Americans. The maxims of Quality and Relation were perceived most deceptive by Hong Kong Chinese; however, Quantity and Manner were not perceived as deceptive compared to U.S. Americans.

Related work discussed in this section suggests that communication frameworks are flexible, and the interpretations of conversational violations, specifically Grice's Maxims, range vastly due to subjectivity originating from non-verbal communication. Additionally, people may adopt different approaches to deal with their subjective interpretations of the conversational violations, leading to a preference to act cooperatively or deceptively. Brosnan and Bshary (2010) suggest using ecological and game-theoretical approaches to investigate the connection between humans' cooperation and deception tendencies. McNally and Jackson (2013) adapted this ecological and game-theoretical approach in a study with primates. They found that while evolutional strategies promote cooperation, they may have been originated from deception and cheating. Through a neuro-cognitive perspective, Lissek et al. (2008) had reported that different activation patterns were observed in the prefrontal cortex when participants attempted to distinguish between cooperation and deception. Furthermore, communicative principles are widely applied to conversational agents and social robots, as reviewed in section 2.3. Thus, applications of flexibility and subjectivity of multimodal communications is a topic of interest for the HCI domain (e.g., Allwood, 1998). Overall, the flexibility of communication can be utilized in systems capable of multimodal communication.

2.5 Summary

The literature review presented in this thesis is motivated by the combination of interdisciplinary work originating from linguistic frameworks and eye-tracking as a methodology to investigate visual cognition and gaze research. The literature review of the theoretical grounds in linguistic frameworks covers the background related to Grice's Cooperative Principle and Neo-Gricean approaches. The related work in visual cognition

and communication frameworks covers various interdisciplinary studies, including human-human interactions and its relation to personality measures. The literature review of this thesis also investigates the related work in potential applications of gaze and conversational violations integrated with technology, namely in the fields of HCI and HRI. Additionally, how non-verbal transmissions of information might impact the flexibility and subjectivity of the interpretations of conversational violations are presented, focusing on deception and cooperation, along with related work in communicative frameworks.

CHAPTER 3

METHODOLOGY

This thesis presents an investigation of gaze and visual exploration patterns of interlocutors in response to task instructions that violate a set of conversational communication principles. The study design consists of an experiment to measure the participants' eye movements and task performance in response to regular task instructions and task instruction, which violate a set of Gricean Maxim violations. The participants' observed behavioral responses were also recorded in the experiment to identify how interlocutors responded to instructions that violated or obeyed the communicative principles. This chapter presents the methodology, including participant demographics, the study design, experimental stimuli, measures, and study procedure.

3.1 Participants

The study included a total of 17 adults (eleven females) who were recruited through canvassing at a university campus (See Table 1). All participants volunteered to attend the study and did not receive any compensation for their participation. All participants were native Turkish speakers. The participants' ages ranged between 22 and 35 years (M = 23.16, SD = 4.89 years). All participants have normal or corrected vision, did not have color blindness, and did not use glasses during data recording. Participants reported their familiarity with LEGO© pieces as M=3.3, SD=0.6 (1= Not familiar, 5= Very familiar). Participants reported their last interaction with LEGO©'s ranged between 2 months to 15 years (M=9.2, SD=5.9 years). Participants' TIPI scores from a 7-point scale (1= low, 7=high) were: extroversion M=5.05, SD=1.67, agreeableness M=5.58, SD=0.84, conscientiousness M=5.38, SD= 1.23, emotional stability M=3.7, SD=1.57, and openness M=5.41, SD=1.30

Table 1. Participant demographic information and personality measure (TIPI) results

Participant	Age	Gender	Extroversion	Agreeableness	Conscientiousness	Emotional Stability	Openness
1	30	M	High	Low	High	Medium High	High
2	26	M	Medium High	Medium High	Low	Low	High
3	34	F	Medium High	Medium Low	Medium Low	Low	Medium Low
4	24	F	Medium Low	Medium High	Medium Low	Low	Medium High
5	24	F	High	Medium High	Low	Low	Low
6	23	F	Medium High	Medium High	Medium High	Low	Medium High
7	30	M	Low	High	Medium High	Medium Low	Medium High
8	22	M	Medium High	Medium Low	Medium Low	Medium Low	Medium High
9	33	M	High	Medium High	Medium High	Medium Low	Medium High

10	23	F	Medium Low	High	Medium High	Medium Low	Medium High
11	23	M	High	High	Medium Low	Low	Low
12	23	F	High	Medium High	Medium High	Medium High	Medium High
13	24	F	High	High	Medium High	Medium High	Medium High
14	23	F	High	Medium Low	Medium High	Medium High	High
15	23	F	Low	Low	Medium High	Low	Low
16	23	F	Low	Medium High	Medium Low	Low	Medium High
17	23	F	High	Medium High	Medium High	Medium High	Medium Low

3.2 Design and Stimuli

To investigate the gaze and visual exploration responses to Gricean maxim violations, a LEGO© building task was designed and conducted in a within-subjects study. For the independent variable, the presence of maxim violations in instructions was manipulated. The dependent variables were the participants' eye-tracking measures (i.e., fixation duration) and task performance (i.e., time spent on completing instructions). The study consisted of six trial sets, and every trial had four tasks. Overall, the study presented a total of 24 tasks. The order of trials was randomized.

Table 2. Structure and contents of the instructions presented for the test trial, i.e., instructions which include neutral statements

Instruction #1	**Instruction #2**	**Instruction #3**
Color + Shape	*Shape + Color*	*Order of the placement*

Each task included three instructions (See Table 2). These instructions aimed to provide information about the color, shape, and order of building for the LEGO© pieces. The first and second instructions presented the color and shape information of the required pieces. The third instruction presented the order of the placement for the first two pieces.

Participants received a total of 72 instructions (i.e., six trials, four tasks, three instructions each) (See Appendix D for the full set of instructions). For each task, one out of three of the instructions demonstrated a violation of Grice's Maxims. The order for the presented violation was balanced to reduce the order effect. Table 3 displays the structural contents of the instructions that demonstrated maxim violations. Only one instruction violated a maxim (seen in Table 3) within each task, and the remaining two instructions were neutral (seen in Table 2).

Table 3. Representative structure and contents for the study trial instructions. The corresponding instructional structure for each maxim violation is displayed.

Violated Maxim	**Instruction #1**	**Instruction #2**	**Instruction #3**
Maxim of Quantity	*Overshared information about the piece*	*Overshared information about the piece*	*Overshared information about the placement*

Maxim of Quality	*Incorrect information about the color*	*Incorrect information about the shape*	*Incorrect information about the placement*
Maxim of Relation	*Unrelated Instruction*	*Unrelated Instruction*	*Unrelated Instruction*
Maxim of Manner	*Ambiguous information about color*	*Ambiguous information about the shape*	*Ambiguous information about the placement*

Example instructions for neutral cases are “take the white, square-shaped piece” for instruction #1, “take the rectangle-shaped brown piece” for instruction #2, and “place the first piece on the platform and place the second piece on its left” for instruction #3.

For example, a violation for the maxim of quantity for instruction #1 and #2 would be “take the piece that is colored gray on each side, has four bumps on the top, four corners, four straight sides, and has a square shape,” and for instruction #3 “place the first piece directly on top of the second piece, and place the second piece directly under the first piece.” Furthermore, an example violation for the maxim of quality for instruction #1 would be, “take the square-shaped pink piece,” for instruction #2, “take the triangle-shaped green piece,” and for instruction #3, “place the first piece inside of the second piece.” Example violations for the maxim of relation would be “count from 0 to 32 in the increments of four” or “list the first seven letters of the alphabet.” Finally, examples for the violation of the maxim of manner for instruction #1 would be “take the brown one,” for instruction #2, “take the square one,” and for instruction #3, “put the piece on the other piece.”

The experiment setup included 18 square-shaped and six rectangular-shaped pieces. The square pieces’ colors were: gray, green, brown, yellow, blue, and white. The rectangle pieces’ colors were: green and brown (see Figure 1). A larger platform was placed below the set of pieces, closer to the participant. The participants used this platform to place the LEGO© pieces after they completed each task.

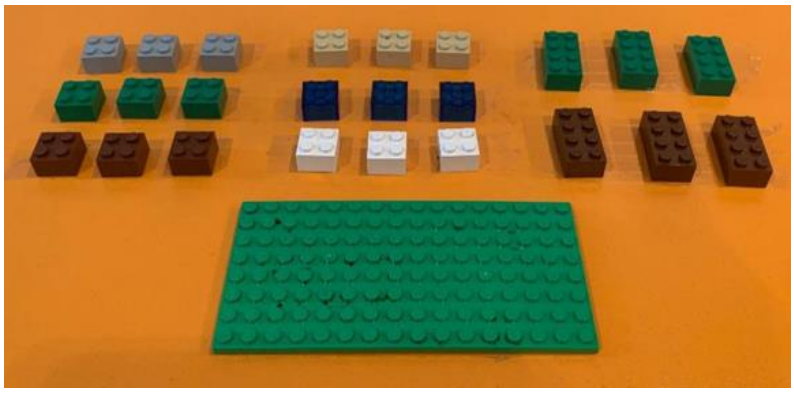

Figure 1. *Experimental Setup:* The figure visualizes the distribution of color and shapes of the pieces. Grey, green, brown, yellow, blue, and white-colored square pieces were followed by green and brown colored rectangle pieces. A larger rectangular platform was placed below the pieces.

The individual pieces were placed 2cm apart, and each group of pieces was placed 5cm apart. The distance between the bottom of the platform and the edge of the table was 35cm, and the distance between the furthest LEGO© piece and the edge of the table was 50cm.

3.3 Measures

The study evaluates a set of objective and subjective measures. The eye movements of the participants were measured using a wearable Tobii Pro Glasses 2 eye-tracker (See Figure 2) with a sampling rate of 100 Hz. The measures for this study consist of fixation duration and interval duration for completing the task. Participants' personality traits were measured in five dimensions (*extraversion*, *agreeableness*, *conscientiousness*, *neuroticism*, *openness*) with the Ten Item Personality measure (TIPI) scale (Gosling et al., 2003). The subjective measures included semi-structured interview which was conducted after the study was completed.

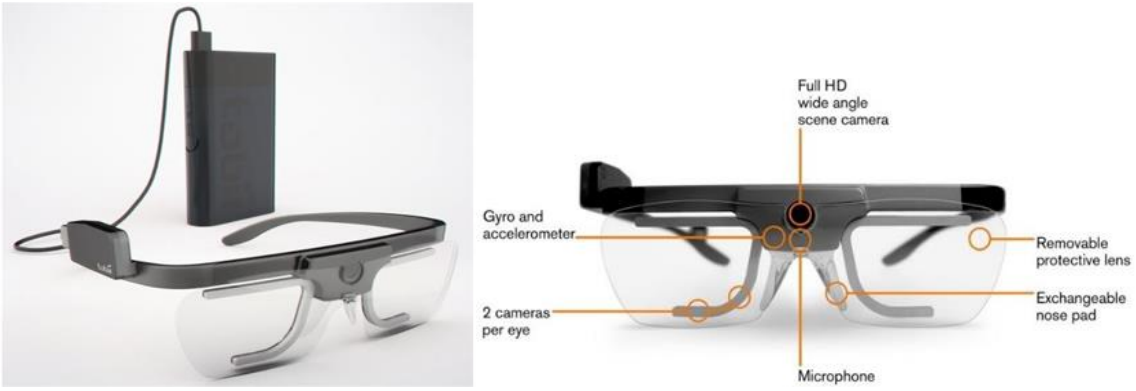

Figure 2. *Tobii Glasses 2 - Eye-tracking Devices:* The figure visualizes the eye-tracking device, Tobii Glasses 2, which was used in this work to measure the eye movements of participants. (Image credit: Tobii LLC)

3.4 Experiment Procedure

Participants attended a LEGO© Building task, in which the experimenter presented multiple instructions to construct different combinations of LEGO© pieces presented in front of them. The study procedure started as the experimenter greeted the participants and provided a written description of the experiment, along with a consent form (See Appendix A). After obtaining informed consent, the experimenter provided a demographics form (See Appendix B) and the TIPI scale (See Appendix C).

Next, the experimenter described a brief function for the eye-tracking device and asked the participant to wear the device. Following the appropriate adjustments to the device, the experimenter initiated the calibration process. After confirming successful calibration, the experimenter started the recording for the eye-tracker.

The experimenter and the participant seated approximately one meter apart from each other with a desk with the study setup placed between them (See Figure 3). The experimenter verbally informed the participants about the study setup and experiment procedure. To reduce the familiarity effect, the experimenter initiated two test trials. The test trials had neutral instructions and did not contain any variable manipulations. During the test trials, participants could ask questions about the experimental procedure. Once the test trials were completed, the experimenter informed the participant that their questions about the study procedure would not be answered until the study trials are initiated. After receiving acknowledgment from the participant, the experimenter initiated the study trials.

For the study trials, the experimenter read the corresponding task instructions to the participant from a printed copy. In order to receive the next task instruction, the

participants verbally expressed when they completed the instruction. After completing the trials, the experimenter conducted a semi-structured post-study interview. Each session lasted approximately 30 minutes.

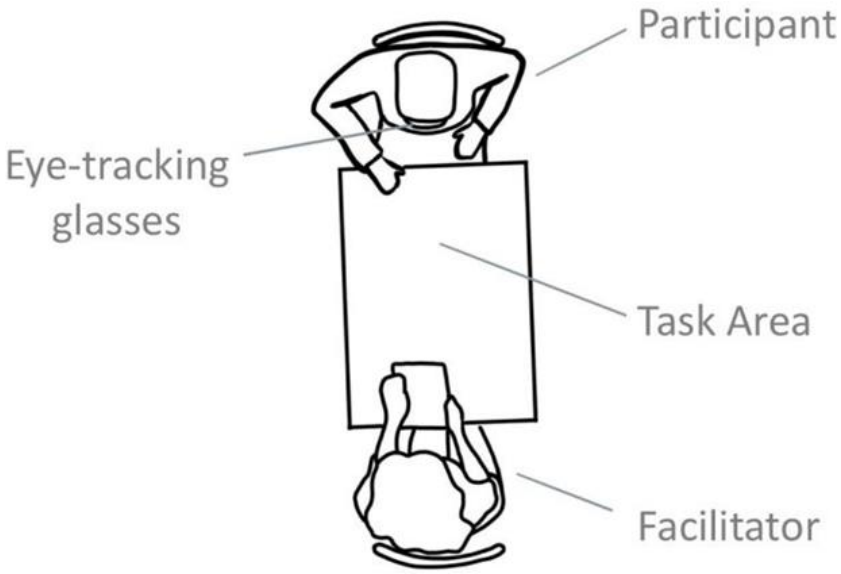

Figure 3. Illustration of the experimental setup

3.5 Quantitative Data Analysis

The software Tobii Pro Lab (version 1.123) was used to analyze the eye-tracking data collected during the sessions. The gaze data of two participants, in which the percentage of gaze samples was lower than 60%, were excluded. The default Tobii Pro IV-T (Attention) gaze filter was used for filtering raw gaze samples. The IV-T Attention filter has the velocity parameter as 100 degrees/seconds rather than the default 30 degrees/seconds. The remaining settings for the Tobii Pro IV-T filter are as follows: gap fill-in disabled, eye-selection average, noise reduction moving median with window size of 3 samples, default velocity window length as 20msec, adjacent fixations merged with max time of 75msecs and max angle of 0.5 degrees between fixations, and fixations below 60msecs are discarded.

All Time of Interest (TOI) points and dynamic Area of Interests (AOI) were manually annotated using the Tobii Pro Lab software. 72 TOI points were created to specify each task's start and endpoints to measure the task performance and response duration. Specifically, the starting TOI point was marked right after the instructor finished reading the task, and the ending TOI point was marked right after the user verbally expressed that

they completed the task. Since some instructions were longer or shorter than others, including the instruction durations to the TOIs could skew the comparative results. Thus, the method for measuring the task performance of participants did not include the fixation durations of the instructions being read to the participants.

Video recordings were analyzed using Tobii Pro dynamic AOI annotations to measure the regions which the participants looked while attempting the task. AOI regions on the dynamic video recordings were divided into four regions: Person Area, Task Area, Peripheral (Left), Peripheral (Right). The regions were manually annotated for each recording timeframe, using the Dynamic AOI Tool provided by the Tobii Pro Lab software. Later, the fixation durations within each area during each TOI were extracted and analyzed for comparison. An example annotation for the dynamic AOI setting is presented in Figure 4.

Figure 4. The setup for the dynamic AOI regions is displayed from the participant's field of view: Person Area (Facilitator), Task Area, Peripheral Area (Left), Peripheral Area (Right)

3.6 Qualitative Data Analysis

Qualitative data analysis was conducted to identify contrasting behaviors of participants for the conditions that included conversational violations. Participant data of the first-person-view video recordings along with the transcribed speech from the post-study semi-structured interview were both investigated for this analysis. The transcriptions identified

from the semi-structured interviews were translated from Turkish to English to present and describe the results in this thesis. The qualitative analysis followed the five steps of Thematic Analysis (TA) identified by Braun & Clarke (2012). These steps are summarized as; familiarizing with the data to identify the potential items of interest, generating initial codes, searching for the themes, reviewing themes, defining and naming the themes, and producing the report.

CHAPTER 4

RESULTS

To identify the effects of Grice's maxim violations within each task, participants' fixation duration and task duration measurements were analyzed using a one-way analysis of variance (ANOVA). In addition, a qualitative analysis was conducted to identify the emerging repetitive patterns and themes observed through the first-person-view video recordings of the participants. The following sections, 4.1, 4.2, and 4.3, present the ANOVA results. Section 4.4 presents the results from the qualitative video analyses and semi-structured post-study interviews.

4.1 Fixation Duration

The analysis compared the fixation durations between *person* and *task* AOI's for the instructions that presented Gricean Maxim violations. The results show that the violation type has a significant effect on fixation duration ($F(2.07, 33.07) = 33.29$, $p<.001$, $\eta_p^2=.67$). Overall, for the tasks instructions that violated Gricean Maxim violations, fixation duration was significantly different between the *person* and *task* AOIs ($F(1,16) = 94.66$, $p<.001$, $\eta_p^2=.85$). The total fixation duration was longer in the task area (M= 6.47s) compared to the person area (M=0.63s).

The combined effects for the Violation Type and the AOI was significant ($F(3,48) =29.95$, $p<.001$, $\eta_p^2=.65$) (See Table 4, Figure 5). The fixation duration was longest in the person area for the maxim of Relation (M=1.09s), followed by the maxim of Quality (M=0.56s), the maxim of Quantity (M=0.53s), and maxim of Manner (M = 0.32s). The fixation duration was longest in the task area for the maxim of Quantity (M=9.19s), followed by the maxim of Quality (M=7.85s), the maxim of Manner (M=4.97s), and the maxim of Relation (M=3.85s). Overall, the longest fixation duration in the person area (M=1.09s) and the shortest fixation duration in the task area (M=3.85s) was for the violations of the maxim of Relation.

Table 4. Mean fixation duration, in seconds, for each AOI and Violation Type

AOI	Violation Type	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Person Area	Quantity	.539	.151	.219	.859
	Quality	.568	.240	.060	1.076
	Relation	1.098	.367	.319	1.877
	Manner	.329	.118	.079	.579
Task Area	Quantity	9.191	.690	7.728	10.653
	Quality	7.852	.904	5.935	9.769
	Relation	3.859	.443	2.920	4.798
	Manner	4.979	.551	3.810	6.148

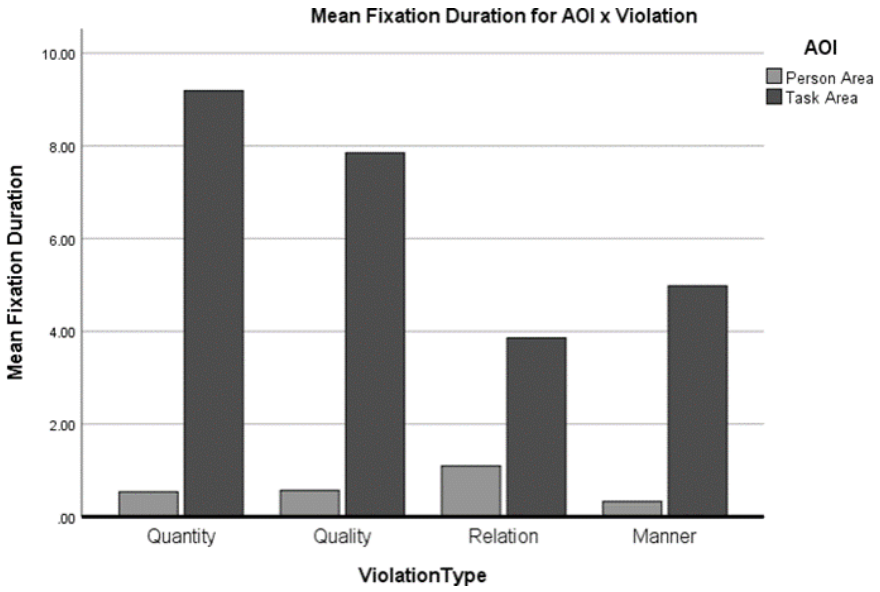

Figure 5. Mean fixation duration, in seconds, for each *AOI* (i.e., person area, task area) and *Violation Type* (i.e., Quantity, Quality, Relation, Manner)

4.2 Response Duration

Task performance in this work is defined as the fixation duration participants spent while attempting to solve the given instructions. To measure the influence of maxim violations on task performance, each task's response time within a violation were analyzed (See Table 5). Mauchly's test indicated that the sphericity assumption was violated ($\chi 2(5) = 22.35$, $p<.001$) for the comparison so a Greenhouse-Geisser sphericity correction was conducted. The violation type had a significant effect on response time ($F(1.681, 26.898) = 12.48$, $p<.001$, $\eta_p^2 = .43$). The average response time was longest for the maxim of Quantity (M=26.79s), followed by the maxim of Quality (M=24.66s), Manner (M=22.30s), and Relation (M=21.89s).

Table 5. Mean response time, in seconds, for completing the tasks with each violation type

			95% Confidence Interval	
Violation Type	Mean	Std. Error	Lower Bound	Upper Bound
Quantity	26.798	.912	24.865	28.731
Quality	24.667	1.573	21.333	28.002
Relation	21.895	.851	20.091	23.698
Manner	22.309	1.018	20.150	24.467

4.3 Task Performance and Personality Measures

The results did not show any significant relation for personality measures and task performance between subjects for violation types. The hypothesis for the personality dimensions and fixation durations were tested and based on the results; Agreeableness ($F(1,11) = 0.19$ $p= .68$, $\eta_p^2 = .016$), extroversion ($F(1,11) = .0$, $p= .99$, $\eta_p^2 = .00$), conscientiousness ($F(1,11) = 0.04$, $p= .84$, $\eta_p^2 = .004$), openness ($F(1,11) = 0.16$, $p= .7$, $\eta_p^2 = .01$), and emotional stability ($F(1,11) = 0.6$, $p= .45$, $\eta_p^2 = .05$), where none of the measures showed a significant effect on task performance.

4.4 Qualitative Analysis

The qualitative analysis included an observational thematic analysis and qualitative coding of the first-person-view video recordings, focusing on the time points where participants were presented with instructions that included any conversational violation. The identified themes, codes, and descriptions are presented in Table 6 and Table 7. Participant responses and selected quotes expressed in the semi-structured post-study interview are also presented in Table 8.

Table 6. Codes and their descriptions used for the qualitative analysis

Theme	Code	Description
Adaptive	Pickup	Participant attempts to pick up an alternative piece. The piece might be unrelated to the piece specified in the instruction or it may share one attribute with the incorrect instruction, such as the color or the shape.
Non-Adaptive	No-pickup	Participant rejected to pick up any piece, ignored the instruction, and behaved as if they followed the instruction without any incorrect information is presented.

The thematic analysis results highlighted a contrasting response between participants where the instruction violated the maxim of Quality (i.e., presented by an instruction that contains incorrect information). All participants displayed one of two contrasting behaviors in the maxim of Quality violation condition (See Table 7), identified as (1) *adaptive*, i.e., seen to attempt picking up an alternative piece even though it does not fit the description of the instruction, and (2) *non-adaptive*, i.e., rejected picking up any piece, faked the hand movement of picking up a piece without actually picking up a piece, and behaved as if they followed the instruction and requested to continue to the next set of instructions. The thematic results show that (1) nearly half of the participants (8 out of

17) were coded under the adaptive condition, while (2) more than half of participants (9 out of 17) were coded under the non-adaptive condition. The adaptive and non-adaptive responses were not significantly associated with any of the demographic information (i.e., gender, age, or personality measures).

Table 7. List of participants with Adaptive (picked-up a piece) or Non-Adaptive (did not pick-up a piece) response to the instructions in violation of the maxim of Quality

Participant	Response Type
1	Adaptive
2	Non-Adaptive
3	Non-Adaptive
4	Non-Adaptive
5	Non-Adaptive
6	Adaptive
7	Non-Adaptive
8	Adaptive
9	Adaptive
10	Non-Adaptive
11	Adaptive
12	Adaptive
13	Adaptive
14	Non-Adaptive
15	Adaptive
16	Non-Adaptive
17	Non-Adaptive

Participant responses transcribed from the semi-structured interviews were analyzed to investigate the results for the adaptive and non-adaptive behaviors further (See Table 8).

The interviewer asked participants about their reasoning for employing the adaptive or non-adaptive responses in the semi-structured interview. Participants who employed *adaptive* responses stated that they did not think much about it, interpreted the instruction, and generally preferred the most relevant pieces to the original instruction (e.g., participants 8, 9, 11, 12, 15). Participants identified under the *non-adaptive* response type generally expressed that they usually ignored the instruction because the required piece "did not exist" (e.g., participants 5, 14, 16, 17). Furthermore, participants expressed that they sometimes felt confused when they were instructed with unrelated tasks (e.g., participants 1, 6, 9, 10, 14). For example, participant 1 expressed their frustration by stating, "the instructions asked for non-existing pieces. You deceived me! … I had a task in front of me, but the instruction did not exist; this was confusing." Overall, the semi-structured interviews showed that participants had some perception of a violation within the instructions, i.e., they stated that they experienced incorrect or unrelated instructions and expressed how they perceived or responded to the instructions which violated their expectations. When asked about the reasoning behind their responses to the unexpected instructions, i.e., instructions with maxim violations, participants stated that they either ignored, skipped, or interpreted the instruction based on their perceptions and adapted their response by completing the task in a semi-related way.

Table 8. Selected participant quotes explaining their reasoning for their approach to tasks with incorrect information

Response Type	Participant	Quote
Adaptive	6	"I tried to interpret the instruction based on my thoughts. I thought to myself that I had to complete a task, so rather than not completing the task at all, I preferred to do it partially correct."
Adaptive	8	"When the instructions asked for a pink piece that did not exist, I interpreted that instruction and tried to pick up the closest color. Similarly, when you requested a hexagon piece, I tried to select the closest shape in my opinion, which was a square piece."
Adaptive	9	"I tried to create a logic myself for each difficulty. I tried to decide based on my perception of the cold or warm

		colors closest to the instruction. I assume there was a strategy for these tasks but I preferred selecting the one that made the most sense to myself. For example, for the pentagon piece I selected the closest shaped piece. In general, I tried to select the ones that I thought were closest to the instruction."
Adaptive	11	"I used my logic to pick up the pieces instructed which did not exist, like the pink or pentagon ones. I could try to combine multiple pieces to create a new color or shape but I did not do that. Mostly I just picked a random one in these cases. I tried not to be creative when deciding.
Adaptive	12	"I tried to pick up a close color or shape. I did not want to give up just because the instructions were incorrect or because I thought I could not complete the task. There was no meaning if I gave up, it would not make sense to give up."
Adaptive	14	"Some instructions were confusing. For example, one instruction asked for a pink piece, which did not exist. Since it did not exist, and there was nothing for me to pick-up, I just said okay and asked for the next instruction. Similarly, for the hexagon piece, I thought about picking up an alternative piece but I decided not to because there were no available pieces satisfying the instruction."
Adaptive	15	"I preferred to select the closest color to pink, it was yellow, and when the question asked for a different

		shape like hexagon I had no choice but to pick up a square."
Non-Adaptive	2	"Most of the instructions were clear. But for the ones which were not as clear I just preferred to skip the instruction. There was no need for me to interpret the instruction based on my thoughts because that would be fooling myself. For the unclear instructions, such as the pink one, there were no pieces under this criterion so I had no flexibility. Whichever piece I picked up would be wrong, so I just decided to skip the instruction."
Non-Adaptive	3	"When the instructions were impossible, I could tell, so I explicitly said that I cannot complete this instruction. However, once it kept happening occasionally, I just ignored the instruction, mocked with the instructions and acted as if I picked up a piece. I did not consider picking up an alternative piece because that would be incorrect, there is nothing pink on this table."
Non-Adaptive	4	"I decided not to do the task when the instruction was incorrect. For example, for the blue hexagon instruction I could have picked up the blue square one, but I refused to do so because although the color is blue it is not a hexagon. I did not pick up a piece unless there was a specific correlation between the instruction."
Non-Adaptive	7	"There were no pink pieces, so I did not pick up any pieces for that instruction. It actually depends on the task. If you asked me to build a house with the pieces, I would try to compensate for the missing pieces. But for

		this task, I was trying to follow the instructions so I did not compensate for the non-existent pieces. I followed the rules. But I am not a person who quits when presented with difficult tasks, I did not pick up an alternative piece because it did not satisfy the instruction."
Non-Adaptive	10	"I did not consider picking up an alternative piece because that would not fit the instructions."
Non-Adaptive	17	"I was not sure what to do when instructions asked for non-existent pieces. For example, the instruction asked for a pink piece but I did not grab anything because there were no pieces identified as pink in my opinion. I usually ignored these instructions."

CHAPTER 5

DISCUSSION AND CONCLUSION

This section focuses on the discussion related to the implications of conversational principle violations on fixation durations and response times, evaluated via eye-tracking measures and discussions highlighting the qualitative analysis results.

5.1 Eye Tracking

The results for fixation duration support the primary hypothesis that maxim violations impact gaze. The results suggest that participants show a longer duration of visual exploration for the tasks that violate the maxims of Quantity and Quality. In addition, shorter fixation durations for the maxims of Manner and Relation suggest the visual exploration was shorter within these tasks.

The eye-tracking results partially support the hypothesis that maxim violations influence visual exploration towards the violator (i.e., person area). The results show that the mean fixation duration in the person area was most evident for the maxim of Relation. As a result of the unrelated instructions caused by the violation of the maxim of Relation, visual exploration tends to shift from the task area towards the experimenter. This visual exploration shift towards the person supports the hypothesis that maxim violations influence visual exploration. However, the violations for the maxims of Quantity, Quality, and Manner have less of an influence on visual exploration towards the person. As a result of violating the maxims of Quantity, Quality, and Manner, the fixations stay mostly within the task area, and rarely shift to the person area.

The fixation duration was highest within the task area for the violation of the maxim of Quantity. This result suggests that the excessive amount of information provided for the

instructions that violate the Quantity maxim influences visual exploration. Participants tend to keep their attention in the task area but partake in visual exploration behavior to compare and evaluate the given information for the task equipment. This thesis's results add on to the related work, which suggests that the presence of overshared information due to the maxim of Quantity might be confusing (Engelhardt et al., 2006). A similar effect was visible but less effective due to the violation of the maxim of Quantity, Quality, and Manner. For the maxim of Quality, the fixations were mostly located in the task area, compared to the person area. This result suggests that when incorrect instructions were present due to violating the maxim of Quality, participants tend to keep their attention in the task area while processing the information. The fixation amount in the task area was lower for the violations of Manner and Relation, which suggests that ambiguous and unrelated instructions have a lower influence in keeping the participants' visual exploration in the task area.

Previous work in the eye-tracking research domain has also indicated that in task-based eye-tracking experiments, participants are expected to have a higher tendency to gaze within the task area. This gaze within the task area is due to the spatial and attentional bias emerging from the nature and requirements of task-based experimentation (e.g., Radach et al., 2003). However, the results presented in this study suggest that some conversational violations can be strong enough to divert the participant's attention from the task area to the person area. Overall, the work presented in this thesis bridges the fields of visual cognition and linguistics with respect to the issues in eye-tracking and communicative principles. This bridge between these interdisciplinary research areas provides an opportunity for future work to investigate the critical factors that influence gaze responses to conversational violations.

5.2 Response Time

The results related to response time support the existing literature related to the decreased task performance as an effect of the maxim of Quality and Quantity (i.e., Jacquet et al., 2019). Through the results of the study, it was seen that the participants demonstrate a longer response time for the tasks that violate the maxim of Quality and Quantity. This rate of response suggests that conversational violations have substantial effects on task performance. Specifically, providing an excessive amount of information (i.e., quantity violation) or incorrect information (i.e., quality violation) decreases task performance. In addition, participants' response time was quicker for the tasks that violate the maxims of Relation and Manner. These results suggest that task instructions that include unrelated information (i.e., relation violation) or ambiguous information (i.e., manner violation) have less influence on task performance.

5.3 Task Performance and Personality Measures

Existing literature shows a correlation between agreeableness scores and the percentage of time participants spend on mutual gaze (Broz et al., 2012). However, for gaze and visual exploration towards the interlocutor, the results do not reflect this correlation between the agreeableness personality measure or the rest of the personality measures (i.e., extroversion, conscientiousness, openness, emotional stability). Thus, the second hypothesis was not confirmed in this work. The results suggest that personality measures may not be a factor in task performance with conversational violations. However, future work is required to investigate the possible connections between personality measures and visual exploration patterns in the context of conversational violations.

5.4 Themes Emerged from the Qualitative Analysis

The qualitative observational analysis yielded some interesting findings in relation to participant responses to conversational violations. One interesting finding was that for instructions which violated the Maxim of Quality (i.e., when participants were presented with an incorrect instruction), the thematic analysis highlighted two distinct behaviors of participants, identified as (1) *adaptive*, i.e., seen to attempt picking up an alternative piece even though it does not fit the description of the instruction, and (2) *non-adaptive*, i.e., rejected picking up any piece, faked the hand movement of picking up a piece without actually picking up a piece, and behaved as if they followed the instruction and requested to continue to the next set of instructions. The process and results of these two responses completely contrast each other. While both responses include a level of *attempted deception* by the participants, it can be argued that the adaptive response is a coping strategy that participants used in order to "*maintain cooperation via gamification."* In contrast, the non-adaptive response is a deceptive strategy used to "*maintain cooperation via attempting a fake perception of success."*

The observed contrast in approaches that participants employed to respond to the conversational violations suggest a *flexibility* component to the interaction. This flexibility seems that it could be interpreted as cooperation attempts within the approach of *gamification* and *attempted deception*, or in other words, attempting to rig the task to achieve success. Due to the nature of the task, since the instructor does not provide any type of feedback when giving instructions, one may suggest that when incorrect information was instructed, some participants decided to step in and adapt their response based on their interpretations, rather than obeying and following what the instructions clearly stated. With respect to the participant responses to the semi-structured interviews, participants who performed an *adaptive* response to Quality violations, i.e., picked up an alternative piece, stated that they interpreted the instruction and decided to select the

pieces most relevant or closest to the original instruction. Participants who performed a *non-adaptive* response to Quality violations, i.e., ignored the incorrect information, did not pick up a piece and asked for the next instruction, stated that their preference to ignore the instruction was because they thought it would be incorrect to take an alternative approach since that was not instructed. In sum, when people encounter instructions with conversational violations, specifically violating the maxim of Quality, their interpretation of how to respond varies in two opposite ends.

Although the exact reasoning behind the adaptive and non-adaptive responses was not investigated within this study, future work can enlighten the factors that weigh the differences in response types of participants. Future research questions may address why participants tend to gamify the task or deceive the instructor when presented with conversational violations, or further investigate the flexibility in interpretations of conversational violations. Furthermore, it would also be interesting to see how this flexibility component in communication might be influential in a study replicated with a conversational agent or social robot acting as the task instructor. Particularly, the results of this thesis highlight an opportunity to investigate the reasoning behind people's tendencies to gamify tasks, deceive the instructor, and try to adapt their responses based on their interpretation of a task when presented with conversational violations (i.e., specifically in the case of incorrect instructions).

5.5 Key Findings

Listed below are the key findings and discussion points based on the experiment results and discussions presented in this thesis.

- Conversational violations in task-based instructions were influential on visual exploration patterns and fixation durations, compared to neutral instructions. The eye-tracking results show a longer duration of visual exploration for the tasks that violate the maxims of Quantity and Quality and shorter durations of visual exploration for the maxims of Manner and Relation.

- Although it is expected for gaze patterns to be dominantly within task areas for task-based eye-tracking studies, the study presented in this thesis showed that participants gazed out of the task area and tended to shift their visual exploration towards the violator for some cases, including conversational violations. This effect was observed most evidently when the instructions violated the maxim of Relation.

- When task instructions violate Grice's cooperative principle, users' response time increased, which resulted in a decreased task performance. This effect was

observed most significantly for the violations of the maxims of Quality and Quantity, followed by the maxims of Manner and Relation.

- Thematic analysis has highlighted two types of responses, an adaptive or non-adaptive approach, when participants were presented with an instruction violating the maxim of Quality, i.e., incorrect information by the instructor. These response types are observed to trigger unexpected approaches for users' cooperation, such as a tendency to deceive the instructor by also gamifying the task. Overall, this suggests a flexibility component in how the violations for the maxim of Quality is interpreted by participants and how this affects the cooperation attempts of users.

5.6 Limitations and Future Work

This thesis consists of an evaluation of the effects of Gricean Maxim violations on gaze and task performance. Although Gricean Maxim's are an established framework, this thesis is limited within this framework and should also be evaluated to investigate the generalizability of the results in relation to other contemporary theories for conversational violations. Future work in HCI and HRI should also investigate the dynamic nature of humans compared to non-human agents in interactions which include conversational violations. For such situations, humans may perceive these violations differently than a computer or robot. Humans might have responses beyond verbal focus (i.e., non-verbal cues and responses), while for social robots, the communicative interactions might be more content-based.

As observed by the qualitative results highlighting the flexibility of different interpretations and non-verbal responses to conversational violations, the work presented in this thesis is limited by the nature of the tasks as part of the study design. The adapted behaviors of users, such as deception and gamification, should be evaluated in a broad context to further investigate the generalizability of the results. Overall, there is a need for designing interactions for communicative agents that approximate these dynamic aspects of interaction. Building on the results and discussions presented in this thesis, future work may uncover how humans respond to or tolerate conversational violations made by non-human conversational agents (i.e., chatbots or social robots), and how these agents' conversational violations affect task performance, fixation duration, visual exploration and gaze patterns of human interaction partners.

This work was limited by the study design. Future work can extend the study design presented to evaluate different effects of Gricean Maxim violations within task instructions. One example extension can be to have the participant read the instructions that include Gricean Maxim violations and investigate their task performance and gaze responses in this setting. Future work can also investigate how participant responses

would differ if the instructor was a robot. A study design that replicates the same set of instructions and tasks but replaces the human instructor with a robot could address research questions related to trust and tolerance of humans when a conversational agent violates Gricean Maxims.

This work was limited by the eye-tracking analysis approach. By applying different analysis approaches, the eye-tracking data collected in this study can be used to answer many research questions in future work. In this work, the eye-tracking analysis compared of all four Gricean Maxim violations as a group rather than comparing the cases that included violations with neutral instructions. One alternative improvement for future work can include an analysis that compares the state right before the violation and right after the violation. For this type of an analysis, the comparison should include both violation and non-violation task instructions. A comparison between the non-violation instructions and violation conditions can uncover more in-depth findings that can explain how instructions types influence task performance.

In addition, the current analysis method focused on the participant responses after the instructions were presented. An alternative analysis can include a holistic approach that includes pre- and post-condition responses of the participants to the conversational violations. This alternative analysis would entail an observation of the gaze behavior of the participant while the instruction is provided, followed by the visual inspection of the participant and the moment they completed the task. However, the instructions should be designed in similar length and difficulties in order to compare conditions that include either violations or neutral instructions. In this thesis, some instructions for different Gricean Maxims were longer than others or included different challenges. These might have affected the fixation durations of participants within the task area. Future work should consider any differences in instruction length and difficulty in which analysis may require percentile comparison rather than total fixation duration.

As a summary, this thesis combines linguistic and cognitive aspects of human interaction, which contributes to the design of gaze patterns in social agents in the context of conversational violations.

5.7 Conclusion

Linguistic frameworks provide a guideline in the design of new technology related to conversational agents and voice interfaces. Paul Grice presents four principles that are influential on the value of dyadic conversations: maxims of Quantity, Quality, Relation, and Manner. In the field of HCI and social robotics, Grice's cooperative principles provide a useful paradigm to implement and evaluate conversational agents. This thesis explored how conversational violations influence visual cognition. To observe the responses to

conversational violations, an experimental task was designed, including a set of instructions that violate Gricean maxims. The experimental setup and tasks evaluated how participants respond to the violations via eye-tracking methods. The results suggest that all four Gricean maxims influence visual exploration and fixation durations. Specifically, the violation of the maxim of Relation causes the participants' visual exploration to shift away from the task area towards the violator. Overall, the violations decrease task performance by increasing response time, most significantly for the maxims of Quality and Quantity, followed by the maxims of Manner and Relation. The qualitative analyses show that participants adapt two contrasting behaviors when presented with incorrect instructions (i.e., violation of the maxim of Quality), namely adaptive and non-adaptive responses. Although the motivation behind these responses is not identified in this thesis, the possible explanations to the contrasting responses were discussed based on the non-verbal modalities observed in the qualitative analysis. Specifically, it is discussed that instructions that violate the maxim of Quality might result in different ways of attempting to deceive the instructor as a cooperation attempt and also as a way to achieve success in the task, which suggests flexibility in the interpretation of the maxim of the Quality violation. Overall, possible applications for future work and how to bridge concepts of conversational violations that emerged with gaze research to the HCI and HRI domain are discussed.

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APPENDICES

APPENDIX A

Katılım ve Bilgi Formu

Deneyimize hoş geldiniz. Bu çalışma kapsamında sizinle bir *LEGO birleştirme görevi* yapacağız. Deneyin başlaması ile yürütücü size çeşitli komutlar vererek önünüzde bulunan LEGO parçalarıyla bu komutları mümkün olduğunca gerçekleştirmenizi beklemektedir. Yürütücü komutları bir kez seslendirecek, herhangi bir tekrar veya soru cevabı çalışma sırasında mümkün olmayacaktır. Çalışma sonunda mevcut sorularınız cevaplanacaktır. Yürütücünün size vereceği komutları mümkün olduğunca gerçekleştirmeye çalışmanız, komutları gerçekleştirirken sesli düşünmeniz ve bir komutu tamamladığınızı düşündüğünüzde bir sonraki komutu alabilmek için "tamam" diyerek sözlü olarak dile getirmeniz beklenmektedir.

Bu çalışma, Doç. Dr. Cengiz Acartürk tarafından verilen COGS 556 Görsel Biliş dersi kapsamında yürütülmektedir. Çalışmaya katılım tamamıyla gönüllülük temelinde olmalıdır. Ön çalışma anketimizde ve ardından katılacağınız deney sırasında sizden kimlik belirleyici hiçbir bilgi istenmemektedir ve bu formdaki isminiz ile sağladığınız verileriniz hiç bir şekilde ilişkilendirilmeyecektir. Deney sırasında video ve ses kaydı alınacak, ancak cevaplarınız isimsiz olarak gizli tutulacak ve sadece araştırmacı tarafından davranışsal olarak değerlendirilecektir – video kaydınız ise sadece göz bakışlarını inceleme amacıyla izlenecektir; elde edilecek bilgiler bilimsel yayımlarda kullanılacaktır.

Çalışmamız kişisel rahatsızlık verecek sorular veya eylemler içermemektedir. Ancak, katılım sırasında komutlardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakıp çıkmakta serbest olacaksınız. Böyle bir durumda yürütücüye çalışmaya devam etmek istemediğinizi söylemek yeterli olacaktır.

Çalışmaya katıldığınız için teşekkür ederiz.

Çalışma hakkında daha fazla bilgi almak için Bilişsel Bilimler bölümü öğretim üyelerinden Doç. Dr. Cengiz Acartürk (E-posta: acarturk@metu.edu.tr) ile iletişim kurabilirsiniz.

Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman yarıda kesip çıkabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda isimsiz olarak kullanılmasını kabul ediyorum.

İsim Soyisim Cinsiyet Doğum Yılı Tarih

İmza

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APPENDIX B

Demografik Bilgi Formu

Bu formda size ait demografik bilgileri doldurmanız istenmektedir.

Tarih	: __ . __ . 2019
Doğum Tarihiniz	: _____
Cinsiyet	: _____
Eğitim Seviyeniz	: _____
Bölümünüz	: _____
Ana Diliniz	: _____
Gözlük kullanıyor musunuz?	**EVET** □ **HAYIR** □
Lens kullanıyor musunuz?	**EVET** □ **HAYIR** □
Renk körlüğünüz var mı?	**EVET** □ **HAYIR** □
LEGO ile aşinalık seviyeniz:	**1 2 3 4 5**
En son LEGO etkileşiminiz:	: _____

APPENDIX C

Katılımcı Kişilik Formu

Kendimi dışa dönük, girişken biri olarak görüyorum
Kendimi başkalarının hatalarını bulmaya eğilimli, kavgacı biri olarak görüyorum
Kendimi güvenilir, disiplinli biri olarak görüyorum
Kendimi endişeli, kolay üzülen biri olarak görüyorum
Kendimi yeni deneyimlere açık, karmaşık biri olarak görüyorum
Kendimi çekingen, sessiz biri olarak görüyorum
Kendimi cana yakın, sıcakkanlı biri olarak görüyorum
Kendimi düzensiz, umursamaz biri olarak görüyorum
Kendimi stresle baş edebilen, sakin biri olarak görüyorum
Kendimi yaratıcı olmayan, geleneksel biri olarak görüyorum

Yönerge: Aşağıdaki ifadelerin sizin için ne kadar doğru olduğunu, ifadenin yanındaki seçeneklerden size uygun olanını işaretleyerek belirtiniz.

Tamamen Katılmıyorum	Kısmen Katılmıyorum	Biraz Katılmıyorum	Kararsızım	Biraz Katılıyorum	Kısmen Katılıyorum	Tamamen Katılıyorum

APPENDIX D

Deney Materyalleri

- Bugün bir LEGO birleştirme görevi yapacağız.
- Her grupta üçer komuttan oluşan dört farklı görev verilecek.
- Her komutu tamamladığınızı düşündüğünüzde "tamam" demeyi unutmayın.
- Gözlüğün altından değil içinden bakın.
- Size göre sağ/sol gerektiren görevler olacak.
- Parçaları çok sert yerleştirmeyin
- Mümkünse sesli düşünmeye çalışın.
- Bu deneme süresince görev tamamlandıktan sonra sorularınızı alabilirim fakat deneye başladığımızda bu mümkün olmayacak.
- Parçaları yeşil platformu yerinden oynatmadan üstünde istediğiniz bir yerinde birleştirin.

Deneme	Instruction #1	Instruction #2	Instruction #3
Quantity	Yeşil renkli kare LEGO'yu alın.	Kare şeklindeki beyaz LEGO'yu alın.	Birinci parçayı ikinci parçanın üstünde platformda birleştirin.
Quality	Kahverengi kare LEGO'yu alın.	Kare şekilli gri LEGO'yu alın.	İlk parçayı ikinci parçanın altında platformda birleştirin.
Relation	Kahverengi dikdörtgen LEGO'yu alın.	Dikdörtgen şekilli yeşil LEGO'yu alın.	İkinci parçayı birinci parçanın sağında platformda yerleştirin.

Manner	Yeşil renkli kare LEGO'yu alın.	Dikdörtgen şekilli yeşil LEGO'yu alın.	İlk parçayı ikinci parçanın soluna platformda yerleştirin.

Yeşil Platformu Temizleyin

Deneme	Instruction #1	Instruction #2	Instruction #3
Quantity	Mavi renkli kare LEGO'yu alın	Dikdörtgen şekilli yeşil LEGO'yu alın.	Birinci parçayı ikinci parçanın soluna platformda yerleştirin
Quality	Gri renkli kare LEGO'yu alın.	Kare şeklindeki yeşil LEGO'yu alın.	İlk parçayı ikinci parçanın üstünde platformda birleştirin.
Relation	Kahverengi dikdörtgen LEGO'yu alın.	Kare şeklindeki sarı LEGO'yu alın.	İkinci parçayı birinci parçanın sağına platformda yerleştirin.
Manner	Beyaz renkli kare LEGO'yu alın.	Kare şekilli mavi LEGO'yu alın.	İlk parçayı ikinci parçanın altında platformda yerleştirin.

Hazırsanız deneye başlayacağız

Trial 1	Instruction #1(**Violation**)	Instruction #2	Instruction #3
Quantity	Her yüzeyi yeşil renkli, kare şeklinde, köşeleri sivri, tepesinde dört adet pütürü, yanları düz ve tabanı boş olan LEGO'yu alın.	Kare şeklindeki mavi renkli LEGO'yu alın.	İkinci parçayı birinci parçanın üstünde platformda birleştirin.
Quality	Pembe renkli kare şekilli LEGO'yu alın.	Kare şekilli sarı LEGO'yu alın.	Parçaları platformun sol alt kısmına yerleştirin.

Relation	Sol elinizi sağ omzunuza, sağ elinizi de sol omzunuza koyun	Kare şeklindeki sarı LEGO'yu alın.	Parçayı platformun sağ üst kısmına yerleştirin
Manner	Kahverengiyi alın.	Dikdörtgen ve yeşil LEGO'yu alın	İlk parçayı ikinci parçanın altında platformda birleştirin.

Görev grubu burada sona erdi. Yeşil Platformu Temizleyin

Trial 2	Instruction #1	Instruction #2(**Violation**)	Instruction #3
Quantity	Beyaz renkli kare şeklindeki LEGO'yu alın	Kare şekilli olan üzerinde dört adet çıkıntı bulunup altı boş olan gri LEGO'yu alın.	Birinci parçayı ikinci parçanın solunda platformda yerleştirin.
Quality	Sarı renkli kare LEGO'yu alın.	Beşgen şekilli mavi LEGO'yu alın	Parçaları platformun orta kısmına yerleştirin.
Relation	Yeşil ve dikdörtgen olan LEGO'yu alın	Alfabenin sondan dördüncü harfini söyleyin	Parçayı platformun sağ alt kısmına yerleştirin.
Manner	Beyaz renkli kare LEGO'yu alın.	Dikdörtgen olanı alın.	İkinci parçayı birinci parçanın sağında platformda yerleştirin.

Görev grubu burada sona erdi. Yeşil Platformu Temizleyin

Trial 3	Instruction #1	Instruction #2	Instruction #3(**Violation**)
Quantity	Beyaz renkli kare LEGO'yu alın.	Kare şeklindeki kahverengi LEGO'yu alın.	Birinci parçanın üzerindeki dört adet çıkıntıyı ikinci parçanın tabandaki boşluklara tamamen kenetleyerek, yanları boş kalacak

			şekilde, birinci parçayı ikinci parçanın altında platformda birleştirin.
Quality	Sarı kare LEGO'yu alın	Kare şekilli kahverengi LEGO'yu alın.	Birinci parçayı ikinci parçanın içinde çapraz yerleştirin.
Relation	Kahverengi kare LEGO'yu alın.	Dikdörtgen şekilli kahverengi LEGO'yu alın.	Onyediden ikiye kadar geriye üçer üçer sayın.
Manner	Gri renkli kare LEGO'yu alın.	Kare şeklindeki sarı LEGO'yu alın.	Bir parçayı diğeriyle platformda yerleştirin.

Görev grubu burada sona erdi. Yeşil Platformu Temizleyin

Trial 4	Instruction #1(**Violation**)	Instruction #2	Instruction #3
Quantity	Her yüzeyi gri olan, köşeleri olan, kare şekilli, tepesinde dört adet çıkıntısı olan, yanları pürüzsüz ve tabanı boş olan LEGO'yu alın.	Kare şekilli mavi LEGO'yu alın	İlk parçayı ikinci parçanın solunda platformda yerleştirin.
Quality	Kırmızı renkli kare şekilli LEGO'yu alın.	Kare şekilli beyaz LEGO'yu alın.	Parçaları platformun sağ üst kısmına yerleştirin.
Relation	Alfabenin sekizinci harfini söyleyin.	Kare şeklindeki yeşil LEGO'yu alın.	Parçayı platformun sağ alt kısmına yerleştirin.
Manner	Yeşili alın.	Kare şekilli gri LEGO'yu alın.	İlk parçayı ikinci parçanın altında platformda birleştirin.

Görev grubu burada sona erdi. Yeşil Platformu Temizleyin

Trial 5	Instruction #1	Instruction #2 (**Violation**)	Instruction #3
Quantity	Beyaz renkli kare şekilli LEGO'yu alın.	Dikdörtgen şekilli olan üzerinde sekiz adet çıkıntı bulunup altı boş, yanları pürüzsüz olan yeşil LEGO'yu alın.	Birinci parçayı ikinci parçanın sağında platformda yerleştirin.
Quality	Mavi renkli kare LEGO'yu alın.	Altıgen şekilli mavi LEGO'yu alın.	Parçaları platformun orta kısmına yerleştirin.
Relation	Kahverengi dikdörtgen LEGO'yu alın.	Sol elinizi başınızın üstüne, sağ elinizi çenenize yerleştirin.	Parçayı platformun sağ alt kısmına yerleştirin.
Manner	Beyaz renkli kare LEGO'yu alın.	Kare olanı alın.	Birinci parçayı ikinci parçanın üstünde platformda yerleştirin.

Görev grubu burada sona erdi. Yeşil Platformu Temizleyin

Trial 6	Instruction #1	Instruction #2	Instruction #3(**Violation**)
Quantity	Gri renkli kare LEGO'yu alın.	Dikdörtgen şeklindeki kahverengi LEGO'yu alın.	İkinci parçanın düz kısmını zemine koyup üzerindeki çıkıntılı parçaları ortalayacak biçimde birinci parçanın tabanındaki boşluklara tamamen kenetleyerek birinci parçayı ikinci parçanın üstünde platformda birleştirin.

Quality	Mavi renkli kare LEGO'yu alın.	Kare şekilli beyaz LEGO'yu alın.	İkinci parçayı birinci parçanın yedi buçuk metre üstüne yerleştirin.
Relation	Kahverengi dikdörtgen LEGO'yu alın	Kare şekilli mavi LEGO'yu alın	On ile elli arasında yediye bölünebilen bir sayı söyleyin.
Manner	Yeşil renkli kare LEGO'yu alın.	Kare şeklindeki sarı LEGO'yu alın.	Diğer parça ile platformda yerleştirin.

Deneyimiz sona erdi.