



Research article

Eye closed learning time by Japanese during an English examination

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ABSTRACT

Purpose: To examine the difference of eye closed learning (iCLOL) time (time during which vision is not required), and the interblink interval (IBI), depending on the learning content, in order to consider the possibility of applying iCLOL to learning.**Methods:** To examine iCLOL time during the listening, writing, and reading sections of an English examination, 19 Japanese subjects were asked to close their eyes whenever it did not interfere with their responses to the examination. Their eyes were video recorded with a video camera, and iCLOL time and the IBI were compared.**Results:** The percentage of iCLOL time during the listening, writing, and reading sections of the examination was $50.7 \pm 10.9\%$, $8.0 \pm 6.5\%$, and $0.9 \pm 1.0\%$, respectively with significant differences among the three. The iCLOL frequency during the listening, writing, and reading sections was 1.64 ± 0.54 times/min, 0.67 ± 0.50 times/min, and 0.26 ± 0.29 times/min, respectively, with significant differences among the three. The IBI during the listening, writing, and reading sections was 3.7 ± 1.7 s, 3.7 ± 1.6 s, and 5.0 ± 2.1 s, respectively; it was significantly shorter for listening and writing than for reading.**Conclusion:** iCLOL time was observed during the English examination, the percentage and frequency of which differed depending on the examination content. At times during the examination when the iCLOL time percentage and frequency were greater, the IBI was shorter. These results suggest that iCLOL may be applied as a method during learning.

1. Introduction

In 2015, the World Health Organization reported that the prevalence of myopia was increasing globally at an alarming rate, with significant increases in the risks for vision impairment [1]. Especially in east Asia, myopia has emerged as a major health issue, because of its increasingly high prevalence in the past few decades (now 80% in school-leavers), and because of the sight-threatening pathologies associated with high myopia, which affects 10–20% of those completing secondary schooling [2, 3].

Tablet computers, smart phones, and other portable information devices have spread dramatically over the past decade, and the time people spend in near work has increased drastically in people of all ages, from children to elderly persons. Students in particular are experiencing an increase in near work time not only during the frequent use of electronic games, but also while studying. There is published evidence that

excessive near work including aspects such as reading or writing distance, time, or posture increases the risk of myopia development and progression [4, 5, 6, 7]. Particularly continuous reading without rests has been shown to lead to myopia [8, 9], and it is thought that students should refrain from near work for long periods. This suggests that students should have regular breaks while reading and writing on test paper. However, despite the general advice in guidelines to take breaks, it is not actually observed by most students. Reasons such as focusing too much or actually being hesitant to take breaks often make it difficult to take breaks during near work. Moreover, appropriate measures for how to use and rest the eyes have not kept up with these changes, and no other specific measures have been established.

We previously proposed a new way for video display terminal (VDT) workers to use their eyes during work [10]. VDT workers encounter periods during which they can perform tasks that do not require the use of sight, such as during intervals between tasks, when switching between

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screens, or when thinking about the contents of tasks. Therefore, at various times they may be simply staring into space without actually looking at the screen or using their eyes. We therefore devised a new method of resting the eyes during VDT work and reducing eye strain by closing the eyes when it would not interfere with the task at hand. There are thought to be numerous advantages of this eye closed (iCLO) method that are not limited to only VDT workers.

While studying, there are also likely to be periods when the eyes are open, but not being actively focused on any one point in particular, such as when thinking. We therefore proposed “iCLO learning (iCLOL)”, during which the eyes are closed for a short period when closing them would not interfere with learning and the person is not actively looking at something. An examination does not represent all aspects of learning, but it is one mode of learning. Therefore, in this study, the eyes of Japanese persons taking an English examination were video recorded, and the times that iCLOL was possible during the examination were investigated to consider the possibility of applying iCLOL to learning. In addition, iCLOL may increase the awareness of blinks, resulting in increased blinking. Since the role of iCLOL may include benefits other than preventing myopia progression, secondary to the shortening of the inter-blink interval (IBI), it was also investigated.

2. Subjects and methods

2.1. Subjects

The subjects were 19 Japanese persons (7 men and 12 women) and their age was 24.1 ± 8.8 (18–51) years. They were students of the same nursing school and their last educational milestone was high school graduation. They took English classes once a week after entering school and passed the school's regular English exams. None of the subjects came into contact with the authors in the hospital and they were recruited to participate in the study by letters. All subjects were given a subject information sheet explaining the study before providing their written, informed consent. None of them suffered from any eye conditions other than ametropia, and all were systemically healthy. No subject had a history of refractive surgery or other ophthalmic surgery, and none were using eye drops. Individuals with tear film breakup time (BUT) ≤ 5 s and those who wore contact lenses when studying at home were excluded.

2.2. Study design

The English examination items were taken from the English examination [11] in the FY 2019 National Assessment of Academic Ability in April 2019. The examination selected was given to third year middle school students by the National Institute for Educational Policy Research, which is under the jurisdiction of the Ministry of Education, Culture, Sports, Science and Technology. Education in Japan is compulsory up to junior high school, and this examination is the only official examination designed to assess achievement in compulsory education departments and areas within those departments and areas. The three areas of listening, writing, and reading in the single subject of English were compared. The examination consists of three sections, listening (problems 1–4; 10-min time limit), writing (problems 9, 10; 15-min time limit), and reading (problems 5–8; 20-min time limit). However, to make the reading section as similar as possible to the other sections and answer times, problem 8 was excluded and only problems 5–7 were used. Since it is not possible to rule out the possibility that blinking could be affected by the content of the test problems, no uniform time limit was established. Each participant was allowed to continue until he/she had finished answering all of the test questions. Incidentally, no score or average score was published for this exam, and the exam responses were not scored.

It was explained to subjects beforehand that the purpose of the study was to investigate the extent to which they used their eyes, and they were asked to close their eyes as much as possible when not needed. They agreed to close their eyes even for short periods when it would not

interfere with the test, such as when they were not actively focusing on one point in particular while thinking. During the examination, 13 subjects used unaided vision and 6 subjects used eyeglasses for refractive correction. A visual acuity test was conducted prior to the English examination to confirm that each subject had acceptable near vision. The ambient temperature and humidity in the examination room were monitored and maintained at ranges 24–26 °C and 30–40%, respectively.

2.3. Measurement

The anterior parts of the subjects' eyes were each video recorded with a video camera. Due to the possibility that the camera placed in front of the subjects' eyes would distract them during the first part of the examination and bias the data [12], subjects were first asked to try iCLOL while answering the questions from the previous year's examination and given sufficient practice in iCLOL. They took a full break before the start of the experiment, and they confirmed that they were experiencing no subjective ocular symptoms. The examination was started at 14:00 to avoid any possible diurnal bias in tear film stability [13]. Adequate rest times were set between the listening, writing, and reading sections of the examination.

For measurements of the IBI, it is preferable to detect blinking in circumstances close to those of natural conditions, since blinking is easily affected by external factors. In the method used in this experiment, it was explained to subjects in advance that this was a study on iCLOL. Since they would then be paying attention mainly to eye closure, they would not be aware that blinking was analyzed when their eyes were open. It was thought that the IBI could be most accurately detected by conducting iCLOL irregularly in a very relaxing environment.

The time that the eyes were closed was measured on the videos, and the iCLOL time and frequency during the examination were calculated. The number of blinks was counted, the IBI was measured, and a comparison was made among the three sections of the examination.

2.4. Ethics statement

This study was conducted in accordance with the Declaration of Helsinki, and written informed consent for voluntary participation was obtained from the subjects. They were informed that great care would be taken to avoid disclosure of personal information, and their consent was obtained for statistical analysis and publication of the results. The study was approved by the ethics committee of Kuwano Kyoritsu Hospital (approval number 190801).

2.5. Statistical analysis

The results are expressed as means \pm standard deviation. An unpaired *t*-test was used in the statistical analyses, and all tests were two-sided. All statistical analyses were performed using SPSS version 22.0 for Windows (IBM Japan, Tokyo, Japan). $P < 0.05$ was taken as the level of significance.

3. Results

The examination times for the listening, writing, and reading sections were 506.4 ± 24.0 (477–553) sec, 538.9 ± 65.0 (440–618) sec, and 540.8 ± 80.1 (404–677) sec, respectively.

The percentage of iCLOL time during the examination in the listening, writing, and reading sections was $50.7 \pm 10.9\%$, $8.0 \pm 6.5\%$, and $0.9 \pm 1.0\%$, respectively. There were significant differences among the three sections (all $p = 0$) (Figure 1).

The number of times iCLOL was done per minute during the listening, writing, and reading sections of the examination was 1.64 ± 0.54 times/min, 0.67 ± 0.50 times/min, and 0.26 ± 0.29 times/min, respectively. There were significant differences among the three sections (all $p < 0.01$) (Figure 2).

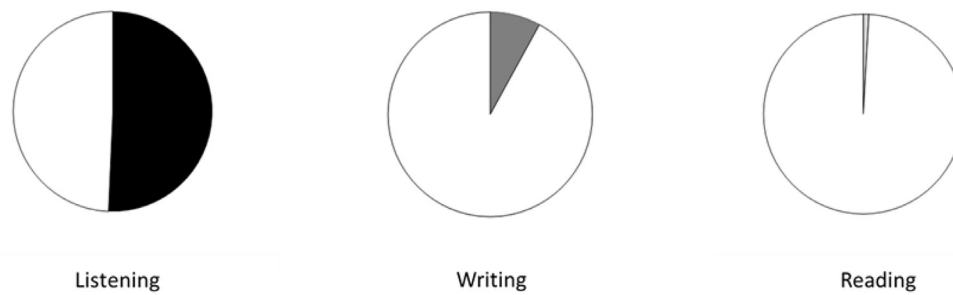


Figure 1. Percentage of iCLOL time during the English examination. There are significant differences among listening, writing, and reading. In listening, the iCLOL time accounts for more than half of the total time.

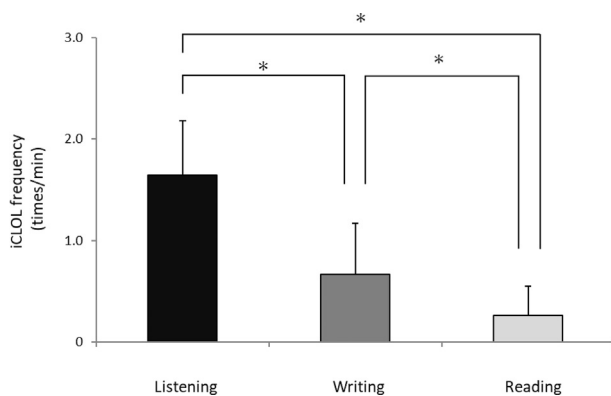


Figure 2. Frequency of iCLOL during the English examination. There are significant differences among listening, writing, and reading. * $p < 0.0$

The IBI in the listening, writing, and reading sections was 3.7 ± 1.7 s, 3.7 ± 1.6 s, and 5.0 ± 2.1 s, respectively. There was no significant difference between the listening and writing sections ($p = 0.95$), but there were significant differences between listening and reading and between writing and reading ($p = 0.04$ and 0.03 , respectively) (Figure 3).

4. Discussion

This is the first study to demonstrate that the period when intentional eye closure is possible (iCLOL time) is also present during learning. The greatest significance of the study is that it demonstrated the period during which iCLOL was actually possible by Japanese persons during an English examination. The proportion of iCLOL time was greater in the

order of listening, writing, and reading, and there were significant differences among the three. The reason that the proportion of iCLOL time was greater in writing than in reading is thought to be that the problem content in writing required more time to think than in reading. Therefore, it is conjectured that, in mathematics, for example, longer iCLOL times would be obtained with problems that require high-level cognition, are difficult, and have little text than with easy problems that involve simple calculations. According to the results of the present study, the mean iCLOL time for listening was more than half of the total time required to answer the questions. This demonstrates that the time during which the eyes do not actually need to be used in order to answer the question without hindrance is quite long during English listening. In situations during which the sense of hearing is mainly used and sight is not explicitly necessary, iCLOL is possible for much of the time. This is not limited to listening while studying, but it also applies to working time (iCLO working). When the sense of sight is not being used for communication, it can be assumed that closing the eyes would not hinder the work in question during specific periods. For example, when operators are speaking and listening on the phone, there are likely to be periods when they are looking at a screen with no particular purpose.

Currently, academic societies in different countries and regions recommend breaks to prevent myopia development and progression. In the guidelines on near work including break times, they state that breaks should account for 1.1–14.2% of total near work time [14, 15, 16, 17] (Table 1). The present study showed that the percentage of iCLOL time during the examination was 0.9–50.7%. Therefore, the results indicated that iCLOL time fully or partially covered the entire break time required during near work, and that iCLOL may shorten the time spent looking at the test paper and the required break time.

As methods for slowing the progression of myopia in students, progressive addition lenses, soft multifocal contact lenses, orthokeratology, low concentration atropine sulfate eyedrops, outdoor activities, and more have been reported [1], but none of them have been widely adopted. Compared with these methods, iCLOL is economical and not complicated since no equipment or drugs are required.

When the eyes are closed, 100% of external light is blocked, and the iris sphincter and ciliary muscle relax, reducing the strain on accommodation function. Therefore, there may be various advantages to iCLOL, other than preventing the progression of myopia, such as less eye fatigue, less dryness, and less exposure to unnecessary light. One of these benefits may be the effect on IBI. In the current study, the IBI was shown to be significantly shorter during listening and writing tasks than during reading tasks. This is a further important finding of this study. Since shortened IBI can also improve dry eye and eye strain, it can be a secondary advantage of iCLOL. Natural blinking in healthy people occurs about 15–20 times/min [18]. Thus, the IBI at rest is 3–4 s. Compared with natural blinking, the blinking frequency decreases and the IBI becomes longer when concentrating and using the eyes [19, 20, 21]. This is thought to be why the IBI becomes longer during reading tasks than at rest. In the present study, the IBI was shorter during the listening and

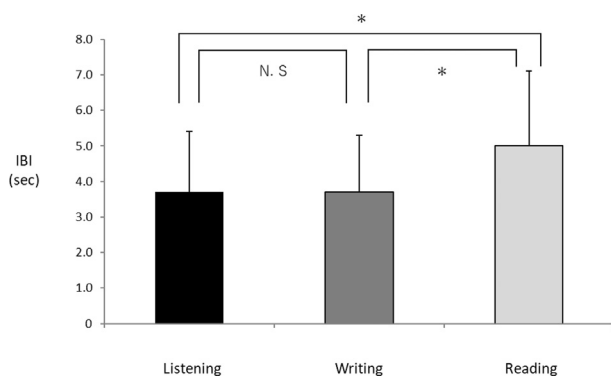


Figure 3. The IBI during the English examination. There is no significant difference between listening and writing, but there are significant differences between listening and reading and between writing and reading. N.S.: Not significant. * $p < 0.05$.

Table 1. Measures for the management of breaks during near work in different countries and regions.

Country and region	Title	Editor
Japan	Preventive Methods of myopia progression for Schoolchildren	Myopia Society Japan
	Take a break of 5–10 min every hour and look at outdoor scenes as much as possible.	
Singapore	Eye Care Tips	Myopia Centre, Singapore National Eye Centre
	Relax your eyes for 3–5 min after half an hour of close-range work or activity (e.g. homework, reading, usage of electronic device).	
Hong Kong	Myopia Preventive Methods	Student Health Service, Department of Health, Government of Hong Kong Special Administrative Region
	Rest for 20–30 s after every 20–30 min of near work.	
United States	Optometric Clinical Practice Guideline Care of the Patient with Myopia	American Optometric Association
	When reading or doing intensive near work, take a break about every 30 min.	

(Refs. [14, 15, 16, 17]).

writing sections of the examination than in reading. This is conjectured to have been due to the difference in iCLOL frequency. In the present results, the frequency of iCLOL was 0.26 times/min in the reading section. Five of the subjects did not use iCLOL at all during the entire reading section, four used iCLOL once, and four used iCLOL twice. Compared with this, it was 1.6 times/min in listening and 0.67 times/min in writing, significantly greater frequencies of iCLOL. We previously reported that the IBI became shorter immediately after iCLO working [10]. The IBI was thought to be similarly reduced after iCLOL in listening and writing tasks. From this, we reasoned that perhaps the longer IBI that occurred from concentrating in taking this test was compensated, as a result of which the IBI achieved a level similar to natural blinking. Moreover, despite the difference in the frequency of iCLOL during listening and writing, the lack of a significant difference in the IBI suggests that if iCLOL is performed regularly, the IBI will not be affected because of the strong awareness of the closure of the eyes.

The benefits of closing the eyes in terms of learning efficiency have also been reported in the past. By cutting off visual information from the outside world, concentration may be improved and learning and work efficiency may be increased [22, 23, 24]. In a study by Glenberg, in both the general knowledge questions and math problems, participants got a higher percentage correct when they did their thinking with their eyes closed [23]. As noted by Zhang, from the perspective of brain science, the brain intrinsic activity in the sensory dominance networks would be enhanced with cutting off visual input from the eyes, and EC would improve other sensory-relative task performances [24]. Eye closure is also reported to improve memory [25, 26, 27]. Nash [25] found that study respondents who closed their eyes scored 23 percentage points higher on a memory test than those who did not. The effect of eye closure was caused by freeing cognitive resources that would otherwise have been involved in monitoring the environment and by promoting visualization of the witnessed event, which improves recall of visual details [27]. Thus, it may be possible to ascribe such benefits to iCLOL. However, it was not possible to assess the impact of iCLOL on learning efficiency in this study, because the examination used in this study did not have a published distribution or average score. Moreover, because iCLOL is irregular and randomized and there are individual differences in iCLOL time, it is impossible to discuss statistically significant differences in the learning efficiency of iCLOL in a small study using methods such as the present one. In fact, our paper on iCLO working did not examine the efficiency of work during iCLO working implementation [10]. If the correlation between iCLOL and learning efficiency is to be investigated in the future, we believe it is necessary to compare the results of examination with the same subjects at the same level of difficulty during iCLOL execution and normal conditions on a large scale.

Eye closure during the day is not limited to iCLOL. Modern people use their eyes for a wide range of purposes, and new ways of using the eyes in various “iCLO ~” shown in Table 2 are thought to be possible depending on how eye closure is practiced in the future. For example, in iCLO

playing of video games, times can be set to rest the eyes for even a short time, such as when starting up or switching screens. In iCLO surfing the net, eye closure could be practiced when there are repeated images, or when there is an image that plainly requires listening only and vision is not needed. In our view, various benefits can be gained from “iCLO ~,” a new way of using the eyes in which the viewer consciously chooses not to receive visual information from the outside world.

To examine the differences between iCLOL time depending on the learning content in this study, first, clear categorization of the areas of examination questions needed to be considered as a top priority. When comparing different subjects, such as mathematics and English, there is concern about differences in individual ability between subjects. Other subjects, such as the home language, had mixed areas of examination questions, and there was no examination that could be categorized into obvious areas as in this examination. For example, in mathematics, even difficult graphic questions that require thinking skills are complex with mixed content, including simple calculation questions, making it difficult to classify the domains objectively. In this respect, each domain was clearly defined in this examination. Furthermore, it is a major problem that the level of difficulty of the exam questions between those areas varies even within the same subject area. In this respect, because this examination was designed by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) to assess learning achievement, the content of the examination has been officially evaluated as being of the same level of difficulty in each domain. Based on the above, this would appear to be the most appropriate examination to use in this study.

Second, the most appropriate subjects were examined according to the difficulty level of the examination. It goes without saying that the third grade students in junior high school are the most suitable subjects for this examination, considering the difficulty level. However, the iCLOL is not difficult once you get used to it, but minors may not be able to perform well on the examination even if they can do well in practice. In addition, it cannot be denied that minors may get into trouble for habitually practicing iCLOL without setting any rules. Considering the above problems, it was decided that minors were excluded from the study and that it was appropriate to conduct the examination in adults first. According to the Basic Survey for Social Life of the Ministry of Internal

Table 2. Various ways of using the eyes called “eye closed (iCLO)~”.

iCLO learning
iCLO working
iCLO playing video games
iCLO surfing the net
iCLO talking on the phone
iCLO memorizing
iCLO playing an instrument
iCLO singing

Affairs and Communications, 8% of the population over the age of 25 years is learning English in Japan [28], so it is not unusual for non-student adults in Japan to learn English. However, Japan's English proficiency was ranked 53rd of 100 countries in the 2019 edition of the EF EPI English Proficiency Index for non-English-speaking countries and territories published by EF Education First (EF) [29]. The test categorizes English language proficiency levels on a five-point scale from "very high" to "very low", with Japan's English language proficiency level in the second lowest category, "low proficiency". This "low proficiency" is defined as "Navigate an English-speaking country as a tourist, Engage in small talks with colleagues, Understand simple e-mails from colleagues", which is roughly consistent with the level of the examination used in the present study. Because the examination is likely to be easier for college students, their final education level was also taken into account. Adults who did not specialize in English as an academic discipline and who were regularly exposed to English were considered the best candidates for the examination, and thus nursing school students were selected. The difficulty level of the examination was also discussed with the professors of their school and it was confirmed that their English ability was appropriate for the difficulty level of the examination. In view of the above, this examination and these subjects appeared to be the most suitable for detecting iCLOL time.

The major purpose of this study was to examine differences in iCLOL and the IBI depending on the content of test problems in a way that was more similar to actual situations, by giving the same English test to subjects. In fact, we thought that it was the content of the test questions rather than the test time that affected the iCLOL, because the iCLOL time varies depending on the content of the questions, even for the same domain. For that purpose, we gave priority to the test problem content over the test time, and we conducted measurements with greater emphasis on making the assessment with uniform test problem content than with uniform test time. Even so, the risk the IBI would be affected for reasons such as eye strain when there are large differences among the three test times for listening, writing, and reading cannot be ruled out. The problems in the three sections, as described in Methods, originally had different time limits. The time limit for the listening section was short, at 10 min, but because the answers were given following voice guidance, the time needed to answer was fairly close to the time limit. The time limit for the writing section was 15 min, but, ultimately, the test time was similar to the time for the listening section. The time limit for the reading section was 20 min, and because a longer time was required for writing and listening in a preliminary examination we performed in advance, one of the questions was deleted. Strictly speaking, with a larger number of subjects, corrections should be made for test times for accurate comparison. In the present study, however, we think that the test times for the three sections could eventually be adjusted to about the same time. For the IBI, to accurately compare the results of the three test sections, it is preferable to conduct the tests under uniform conditions. For a rigorous assessment of the shortened IBI during writing and listening compared with reading, measurements of the IBI should be conducted when iCLOL was not performed as a control. However, repeating the same test in the same subjects is not possible, and, moreover, the individual differences in the IBI are large, and a considerable number of subjects would be necessary to compare the IBI in different populations. Therefore, it would have been difficult in the present study. In the future we would like to increase the number of subjects and measurement conditions, and continue with a larger scale study.

Teaching students to practice iCLOL during near work for long periods, such as when studying or using a computer or mobile phone, is itself beneficial for their eyes. Moreover, as a measure to mitigate the progression of myopia, iCLOL fulfills the necessary conditions of having no serious side effects, being economical, and not being complex. However, if iCLOL is to be adopted, it should be done carefully under the supervision of teachers or parents. One's own safety and the understanding of people nearby are major prerequisites. It goes without saying that guidelines and rules are necessary for using iCLOL, but even

assuming that guidelines and rules have been established, there is no guarantee that students would always follow them. Sight accounts for 80% of information from the outside world, and there is concern that blocking it completely may end up causing various problems in terms of safety. Considering the above, it cannot be denied that there are major hurdles to the practice of iCLOL by students. Even in adults, there is a risk of overlooking something important or the occurrence of trouble in communication due to iCLOL, and the time, place, and other circumstances for iCLOL must be selected. Attention to the effects of eye closure for long periods in people who wear contact lenses is also required.

5. Conclusion

In the present study, some iCLOL time was observed by Japanese during the English examination, and it was shown that there were differences in its percentage and frequency depending on test content, and that when the percentage and frequency of iCLOL time increased during the examination, the IBI became shorter as a result. These results suggest that iCLOL may be applied as a method of using the eyes while studying.

Declarations

Author contribution statement

H. Fujita, K. Sano: Conceived and designed the experiments; Wrote the paper.

K. Takeuchi, T. Kikutani, M. Azuma: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

T. Tanaka: Performed the experiments; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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