Eye-key Span as a Measure of Cognitive Effort in Translation: A Study on the Influence of Directionality on Cognitive Effort

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ABSTRACT

This exploratory study aims to analyze the influence of directionality on cognitive effort operationalized in the eye-key span (EKS). Following the definition developed by Dragsted (2010), EKS is measured as a time lag that lasts from the last fixation on the analyzed point of interest in a ST to the moment when a translator starts translating it. A set of collocations occurring in the Polish and English source texts was defined as the "point of interest" for the study. The data were collected from 25 translation trainees using eye-tracking and keylogging. Participants worked in both directions in the Polish-English language pair. It was hypothesized that the participants would produce longer EKS in the L1-L2 translation direction. Although the descriptive statistics revealed differences in the mean duration of the EKS and in the data distribution that were visible on histograms, the results of the inferential statistics did not reach the level of statistical significance. The adopted hypothesis was not confirmed.

KEYWORDS: cognitive effort, directionality, EKS, translation trainees, translation process

1. Introduction

Time lag, defined by Šárka Timarová and her colleagues (2011: 121) as "the temporal delay between source text (ST) input and target text (TT) output," is described as a reliable measure of cognitive effort, requiring the use of the latest process methods. They continue to explain that "[t]ime lag provides insight into the temporal characteristics of simultaneity in interpreting, speed of translation and also into the cognitive load and cognitive processing involved in the translation/ interpreting process" (ibid.). There are various types of time lag

measurements. Ear-voice span (EVS) is measured in simultaneous interpreting (for example, Gumul 2006 and Chmiel et al. 2017). Eye-voice span (IVS) is used to study time lag in sight translation (for example, Chmiel and Lijewska 2022 and Wenchao 2023). Chen (2020) attempted to analyze the time lag in consecutive interpreting by introducing an ear-pen span. In the case of translation, only eye-key span (EKS) can be measured. EKS is defined by Dragsted (2010: 50) as "the time lag between a fixation on an ST [source text] word and the first keystroke related to producing its TT [target text] equivalent." Nevertheless, Timarová et al. (2011: 134) pointed out a significant research gap, stating that there is a scarcity of studies analyzing the topic of EKS in translation. To the best of my knowledge, only a few studies exploring this issue appeared since 2011, and none of them analyzed EKS solely among translation trainees. Since translation trainees have not developed the automation of the translation process, frequently associated with professional translators, their performance could provide valuable information about the cognitive effort. Moreover, Timarová et al. (2011: 122) suggest that "time lag [for example, EKS] is indeed a sensible variable reflecting interpreters' and translators' cognitive processing." Therefore, I analyze EKS as a measure of cognitive effort in a new, under-researched spectrum, which is translating in and out of the native language (i.e., directionality) performed by translation trainees. It is worth noting that the influence of directionality on the translation process is believed to need further investigation. This topic has not been analyzed based on the EKS yet. Interestingly, in the existing studies, the EKS was usually measured based on random word pairs. However, a study analyzing the EKS based on fixed units of texts, like collocations, can hardly be found. Thus, this study, which is part of a broader research project, aims to investigate the influence of directionality on cognitive effort, which is operationalized in EKS. In this study, the EKS is measured based on collocations defined by Teubert (2004: 174) as units of meaning with "the co-occurrence of two or more words" (see Appendix).

Since I address the issues of directionality and cognitive effort operationalized in the EKS, I would like to begin with a literature review discussing the current state of research on the influence of directionality on cognitive effort. Because EKS has not yet been analyzed in the context of directionality, I move on in the next section, to the issue of the EKS. I put a particular emphasis on two manners of measurement and the current state of research. Next, I discuss the study's design and present the analysis and discussion of the results. I also devote

attention to the important limitations of this study and provide some suggestions for possible further implementation of the EKS in the context of directionality and the process of translating collocations.

2. Directionality and Cognitive Effort

According to Whyatt (2019: 79), directionality refers to whether translators "work into their first or 'native' (L1) language or out of their L1 and produce translations into their 'first foreign' language (L2)." De Lima Fonseca (2015: 123) observes that the L1-L2 translation direction is frequently believed to require significantly higher cognitive effort compared to the L2-L1 direction. Nevertheless, since the beginning of the 21st century, researchers have employed various translation process methods to verify this view.

The notion of cognitive effort has been present in translation and interpreting studies for years. For example, Gile (1995) developed an Effort Model, referring primarily to various modes of interpreting. There have been numerous attempts to define cognitive effort and its relation to cognitive load (for example, in studies by Seeber 2013, Ehrensberger-Dow et al. 2020, Gieshoff and Hunziker Heeb 2023). However, while referring to cognitive effort, I will follow a recent definition of translator effort developed by Hunziker Heeb (2020: 48), who defines it as "[t]he total effort the translator expends during the translation task [and] the target text is then the product of this translator effort." A straightforward relationship between the cognitive effort and translator effort can be observed. Hunziker Heeb (2020: 66) considers "different indicators of effort as different representations of the same cognitive effort and not as different types of effort. I, therefore, do not distinguish between (…) technical, temporal or cognitive effort but instead, call it translator effort." Many researchers have tried to verify whether the L2-L1 translation direction can be unambiguously related to a decreased cognitive effort. This discussion holds a special place among countries where the L1-L2 direction is a common translation practice. This can frequently be observed in countries that use languages of limited diffusion, defined as languages that are "not widely used outside [their] primary linguistic community or frequently acquired as a second language" (Pavlović 2007b: 7). Countries like Poland, Czechia, and Croatia belong to this group (Pavlović 2010, Whyatt and Kościuczuk 2013, Mraček 2018).

It should be emphasized that the studies discussing the influence of directionality on cognitive effort led to inconclusive results. Only some studies confirmed that the L1-L2 translation direction evokes higher cognitive effort. For example, Buchweitz and Alves (2006) utilized keylogging to analyze the translation process in the Portuguese (L1) – English (L2) language pair. By comparing total task time, segmentation of the TTs, and the keystrokes used for revision, they unequivocally showed that L1-L2 translation is more effortful than the L2-L1 direction of translation.

Pavlovič and Jensen (2009) used eye-tracking to analyze the influence of directionality on cognitive effort in the Danish-English language pair, with Danish as the participants' L1. Interestingly, they fully confirmed only one out of four hypotheses. Statistically significant results show that regardless of the translation direction, participants struggled with higher cognitive effort while processing the TT rather than the ST. Moreover, two out of four hypotheses were partially corroborated. The results from only one variable indicated that L1-L2 translation in general and TT production during L1-L2 translation require higher cognitive effort. Pavlovič and Jensen (2009) also did not manage to confirm that ST processing requires higher cognitive effort during L2-L1 translation. What is more, some of the variables analyzed in their study point to a reverse trend, according to which the L2-L1 translation direction requires higher cognitive effort.

Eye-tracking was also utilized to study directionality by Ferreira and her colleagues (2016), who focused on the Spanish-English language pair. The data indicated that the L1-L2 translation direction may evoke higher cognitive effort. This hypothesis was confirmed by statistically significant results from total task time and fixation count. Ferreira and her colleagues also partially confirmed that translators need more cognitive effort to process ST during the L1-L2 translation. However, the obtained results did not allow them to conclude that L2 TT processing requires more effort and that translators tend to spend more time in the Internet browser during the L1-L2 translation. It should also be noted that the analyzed group was very small, as it included only four participants. Quite the opposite results could be found in the latter study by Ferreira and her colleagues (2021). This time, they analyzed eye-tracking and keylogging variables. However, the results from only one of the eye-tracking

variables, gaze event duration, indicated that the L1-L2 evokes significantly higher cognitive effort. The remaining results did not reach the level of statistical significance.

Another example of studies analyzing the influence of directionality on cognitive effort are the works by Whyatt (2018, 2019), who, like this study, focused on the Polish-English language pair. Utilizing eye-tracking and keylogging, Whyatt observed that the orientation phase (Jakobsen 2002) is more cognitively demanding in the L2-L1 direction. This means that participants have to invest more cognitive resources to analyze the ST written in their L2. However, not all variables analyzed in the drafting phase indicated that more effort is required by the L1-L2 translation direction since the differences between the two directions were minimal. Likewise, the revision phase was only slightly longer in the L1-L2 translation. Thus Whyatt (2019) concluded that these results did not indicate L1-L2 as a more cognitively demanding translation direction.

3. Eye-key Span as a Measure of Cognitive Effort

The definition of the eye-key span (EKS) developed by Dragsted (2010: 50) was already mentioned in Section 1. The main idea behind EKS lies in the length of typing inactivity that occurs from the last fixation on a given point of interest in a ST to the moment of its translation. Timarová et al. (2011: 122) pointed out that the main advantage of EKS lies in its objectivity and relative ease of observation. Moreover, they believe that EKS can be analyzed as a valuable measure of cognitive effort (Timarová et al. 2011: 121). Thus, they highly emphasize the need for further and consistent investigation of EKS in translation process research. However, it should also be noted that triangulating very precise eye-tracking and keylogging data, such as fixations as keystrokes, that are required to analyze EKS may also be a time-consuming process.

Two main manners of measuring EKS prevail in translation process studies: from the first fixation until a word is being typed and from the last fixation until a word is being typed. However, as suggested by Dragsted (2010: 51), any fixation that appears between these two points can serve to measure EKS. The first manner of measuring is believed “to span the entire preparation or planning phase preceding the production of a word” (Dragsted 2010: 51). The possibility of tracing back the planning process that precedes translating points of interest

is a huge advantage that may lead to the identification of main problem triggers. For example, in the study by Dragsted (2010: 54), a student fixated multiple times on a word that caused difficulties before they managed to translate it. The process of measuring EKS from the first fixation also has some drawbacks. Apart from refixations on the points of interest, people tend to additionally look at many different words in the text, which may be a distorting condition. Another important factor is that reading the whole text beforehand is not always a common practice among translation trainees and professionals. Dragsted (2010: 52) observes in her study that "[t]here were no indicators in the data that any of the participants read the whole text before they started translating it (possibly because they had already done so during the reading-for-translation task)." Thus, a problem in defining the concept of first fixation emerges. Only some participants may produce the first fixation on the analyzed point of interest as early as during the orientation phase.

The second manner of measuring EKS is from the last fixation until the analyzed word is being typed. Dragsted (2010: 51) points out that it "invariably involves a coordination/transformation effort, because, during this time span, a fixation on an ST word is actively transformed into a TT equivalent which is typed in the TT window of the screen." Therefore, it "indicates the immediate effort of switching from the reading mode to the writing mode" (ibid.). Moreover, EKS measured from the last fixation gives the researchers the possibility to examine whether the participant is able to coordinate work on the ST and TT or whether they have to work in turns. It usually distinguishes professionals from translation trainees. However, some distortions in the form of fixations on words other than points of interest may also appear in this case (Dragsted 2010: 52).

EKS has probably been most thoroughly discussed by Dragsted (2010) and Timarová et al. (2011). In her study, Dragsted (2010) focused on the analysis of coordination of the translation process and source text comprehension. She compared the results of translation trainees and professional translators. The task of 14 students and eight translators was to read and then translate a short text from English (L2) into Danish (L1). Thirty random words constituted points of interest. The results indicated that students tend to exhibit a longer EKS than professional translators. This suggests that in contrast to professional translators, translation trainees have not yet developed the ability to coordinate ST reading and TT

writing. Thus, their translation behavior could be described as sequential coordination, as they process both texts separately.

Timarová and her colleagues (2011) analyzed EKS in various conditions and among various subjects, based on random 30-word-pairs points of interest that varied between the subjects. They focused on the following categories: intra-subject analysis, inter-subject analysis, analysis of the EKS based on parts of speech and sentence position, and comparison of the EKS during translation and copying tasks. They studied two groups of participants: translation trainees and professional translators. Like Dragsted (2010), Timarová and her colleagues (2011) observed differences between translation trainees and professionals. The translation process of trainees is characterized by many fluctuations. At the same time, the EKS produced by professionals was stable both when analyzed from the first and from the last fixation. Additionally, professionals produced shorter EKS values than translation trainees. During the inter-subject analysis of students' translations, Timarová et al. (2011) observed frequent refixations or fixations on various words preceding the translation of points of interest. Professionals usually manage to produce their translations right after reading a given word. Interestingly, the analysis of the EKS in relation to parts of speech did not reveal any trend, as outliers tend to appear among all parts of speech and in all sentence positions. Finally, a correlation was observed between EKS in typing and copying tasks performed solely by professionals. However, Timarová and her colleagues (2011: 134) highlight that the obtained results may be influenced by the differences in typing behavior among participants.

Another study in which EKS is the subject of analysis is the work by Schaeffer and Carl (2017), who studied EKS from the first fixation. They replicated the study design by Dragsted (2010), introducing as many as five target languages. The results suggest that EKS may be influenced by features such as the length, frequency, and position of words for which EKS is analyzed. The results of the study by Schaeffer and Carl (2017) showed that translation trainees tend to produce longer EKS values than professional translators, which was in line with the results obtained by Dragsted (2010). Shorter EKS values were also observed in the coping task rather than the translation task.

4. Aim and Hypothesis

The aim of this study is to analyze the influence of directionality on cognitive effort operationalized in the EKS. Following the categories introduced by Dragsted (2010: 51), I am interested in the EKS measured from the last fixation as it allows me to analyze the immediate cognitive effort appearing right before translating points of interest. Although EKS has not so far been analyzed in the context of directionality, there are other eye-tracking and keylogging variables which have been analyzed, for example, in studies by Pavlović and Jensen (2009), Ferreira et al. (2016) or Whyatt (2019) as discussed in Section 2. These indicate that the L1-L2 translation may require higher cognitive effort. Following these studies, I predict that participants of this study will produce longer EKS in the L1-L2 direction, whichh translates into increased cognitive effort. The language pair analyzed in this study joins the language of limited diffusion (Pavlović 2007b), Polish, with the contemporary lingua franca (Pavlović 2007a, Rodríguez-Inés 2022), English. It should be emphasized that in the case of the Polish translation market, translation frequently occurs in both directions between Polish and English (Whyatt and Kościuczuk 2013).

Participants translated short texts, one in each direction; however, I chose collocations as my points of interest (See details of the source texts in Section 5.2). The rationale behind this was the results obtained in my previous study (Pietryga 2022). It showed that participants identified vocabulary, including collocations, as a main problem trigger regardless of the translation direction. Moreover, researchers are unanimous that although collocations play a crucial role in fluent language speaking, they frequently pose a serious problem in foreign language acquisition and, consequently, also in the translation process (Wolter and Yamashita 2015, Pellicer-Sánchez et al., 2022, Sonbul et al. 2022). There is a considerable research gap in the analysis of the EKS in the context of collocations and directionality. Previous studies, for example, by Dragsted (2010), Timarová et al. (2011), and Schaeffer and Carl (2017), focused on different units like random single words and compared the translation process of professionals and trainees. All of them focused on translation performed from foreign into native languages, which is believed to require less cognitive effort. This study analyzes EKS, particularly within the group of translation trainees, which allows insight into the translation process occurring in their minds which are frequently referred to as the “black boxes” (for example, in studies by Dragsted 2010, Chmiel 2020, Rojo López and Muñoz Martín 2022). Since EKS has not been analyzed in the context of directionality before, my study can be

characterized as exploratory. I will test a theoretical model suggesting that participants may produce longer EKS in the L1-L2 translation direction. The study received a positive opinion no: KEUS192/12.2021 issued by the Ethics Committee at the University of Silesia in Katowice.

5. Methodology

5.1 Participants

Thirty-five 5-year advanced translation trainees (who have been in higher education for five years, including three years of the BA program and 2 years of the MA program) attending the translation and interpreting program at the University of Silesia in Katowice participated in this study. Translation trainees took part in the study right before their MA thesis defense. Although all participants reported normal or corrected-to-normal vision, the data from 10 of them had to be discarded due to some calibration issues. Therefore, the final sample comprises 25 translation trainees (21 women and four men). Their age ranged from 23 to 24 years old (M= 23.9; SD= 0.78). Following good practices and suggestions of the Ethics Committee, all participants received university merchandise, such as USB sticks, pens and notebooks as a form of compensation for their work and time.

Participants' L1 was Polish, and L2 was English. According to the University curriculum, translation trainees are taught translating both in and out of their L1. Therefore, they are supposed to demonstrate proficiency in both translation directions. Moreover, all participants completed at least 90 hours of translation training devoted to practicing both L1-L2 and L2-L1 translation. It is worth noting that contrary to many Western European universities; there is a common practice to teach both L1-L2 and L2-L1 translation and interpreting at Polish universities (Gumul 2017: 314). However, I decided to additionally verify participants' skills in both languages to avoid confounding variables in the form of poor knowledge of English.

Since Polish is the participants' native language, I decided to first assess their proficiency in English. Many researchers use the Lextale test for this purpose also in the context of directionality (for example, in studies by Whyatt 2018 and Jankowiak and Lehka-Paul 2022). The Lextale test is conducted via an online platform, and the participants' task is to decide

whether a word they see on the screen can be an existing English word. As the authors of the test, Lemhöfer and Broersma (2012: 326) point out, "[t]he target population of the test is adult learners who started learning English at school at an age of about 10-12 years, which is standard in many countries, and who continue to use English in daily life." For example, in the study by Chmiel and Lijewska (2022: 7), the participants' mean results in the Lextale test were 89.31, which they assessed as "indicating very high, close to native-like proficiency for most of the participants." Participants of this study obtained the mean Lextale test results at the level of 77.3 (SD= 11), which means that they demonstrated high proficiency in English. The second measure used in this study was the self-assessment grid table prepared by the Council of Europe (2001), designed to be used in multiple languages. Participants' task was to assess their six skills in L1 and L2. These are listening, reading, spoken interactions, spoken production, and writing. They all assessed their abilities in L1 as being at the C1-C2 level. In the case of L2, the participants also indicated the C1-C2 level, with just a few cases in which the B2 level was reported. The results indicated that the abilities required for translating were assessed as being at equally high levels in both directions. To avoid a confounding variable in the form of too-slow typing, participants' typing speed in L1 and L2 was also measured. They demonstrated comparable typing skills in both languages. In the case of Polish, the average typing speed was 47.4 words per minute, while in the case of English, 44.9 words per minute. The details of the participants' skills are summarized in Table 1 below.

Table 1. Details of the participants' skills

Participants' skills	**L1**	**L2**
Proficiency	native	77.3% (Lextale test)
Listening	C2	B2-C2
Reading	C1-C2	C1-C2
Spoken interactions	C1-C2	B2-C2
Spoken production	C1-C2	B2-C2
Writing	C1-C2	C1-C2
Typing speed	47.4	44.9

5.2 Materials

The materials used for the study are two authentic texts, one in Polish and one in English, obtained from the National Geographic website. The website contains texts that can be classified as popular science texts. Participants were not familiar with the content of the text before the study. However, the texts do not contain highly specialised vocabulary and resemble the materials and the difficulty level that students were used to during their translation classes. Therefore, I chose them as source texts for this study. Both texts were related to the topic of animals: tortoises and dogs. The Polish text discussed the topic of the oldest tortoise in the world, and the topic of the English text was the processing of praise by dogs. The texts were modified to fit the purpose of this study. They were counterbalanced in terms of length, difficulty, and the number of collocations appearing in each text. Each text contained collocations[1] obtained from the well-known corpora British National Corpus (2004) and Narodowy Korpus Języka Polskiego (2012). Initially, there were 14 collocations in each text; however, as some of them occurred too close to each other in the text and may be wrongly perceived as one long phrase, I decided to reduce the number of collocations to 12 in each text. Collocations were controlled for their frequency and difficulty level. Although my modifications of the source texts were limited by the content of the original texts and requirements of the eye-tracking software, I managed to apply common and well-known collocations in both languages. According to the frequency data obtained from the corpora, the analyzed collocations belong to the 25 most frequent collocations in each language. All of them are composed of words that are known to translation trainees. Only the collocation ‘to respond correctly’ was noted as the 46th most common collocation, including the verb ‘to respond.’ The difficulty of the texts was also assessed through the readability formula, the Fog Index. The Polish text was assessed at 11 points and the English text at 11.3 points, meaning that at least secondary education is required to understand both texts. Thus, the results indicated similar difficulty levels of both texts. The length of the Polish text was 168 words, and the English text had 171 words. The details of the materials are presented in Table 2 below.

[1] The list of collocations is included in the Appendix.

Table 2. Details of the source texts

	POLISH TEXT	ENGLISH TEXT
Length	168 words	171 words
Fog index	11	11.3
Number of collocations	(12)14	(12)14
Frequency of collocations	25 most common collocations	25 most common collocations + one collocation listed as 46th most common

5.3 Equipment

To analyze EKS, the researcher has to record eye-tracking and keylogging data. Eyelink Portable Duo eye-tracker was utilized to record participants' gaze data. The eye-tracking data were recorded monocularly at the sampling rate of 1000 Hz with 13-point calibration. Since the remote mode was used, participants could move their heads freely. As a result, it did not restrict their usual use of the screen and the keyboard during the translation process, increasing the ecological validity of the study. However, participants were asked to substantially reduce their movements to avoid losing eye-tracking data. The typing data were recorded by the keylogging program Translog II (Carl 2012). The texts were presented in black font, size 22, double-spaced, on a grey background.

5.4 Procedure

The experiment consisted of three tasks in two directions, L1-L2 and L2-L1, preceded by some pre-tests. The order of directions of translation was randomized by Randomiser.org to avoid fatigue resulting from the length of the experiment. The experimental tasks were translation, retrospective session, and filling in some questionnaires. The scope of this article is limited to data obtained solely during the translation task. The data were collected between April and June 2022 at the University of Silesia. At the beginning of the experiment, participants were informed about the course of the study. They also gave written consent for participating in the study and recording and analyzing their data. Participants were also presented with the General Data Protection Regulation form and informed that they should

work at their normal pace, as there were no time constraints. Nevertheless, using any online or paper resources was forbidden. It is believed that such behavior may significantly decrease the perceived cognitive effort, which is analyzed in this study. After the calibration process was finished and the equipment was prepared to record the data, the experimental procedure began.

5.5 Data analysis

As already mentioned, the EKS was measured as a time lag that passes from the last fixation on a given collocation to the moment the first key was pressed to translate it. Because I was interested in the immediate cognitive effort leading to a correct translation, I decided to exclude EKS that appeared before all the inaccurate or incomplete translations. After the experimental procedure was finished, I extracted translated collocations from the translated texts. In the next step, four experts assessed translations of collocations in terms of their accuracy. The experts were linguists and native speakers of either Polish or English. For the purpose of the accuracy assessment, the scale proposed by Andermann and Rogers (1997: 61) was adopted. They introduced three categories: 'task not completed,' 'task partially completed,' and 'task completed.' The scale was created for educational purposes to assess translations produced by students. I also decided to assign 0-2 points to each category in my study. 0 points were assigned to the category of 'task not completed,' 1 point was assigned to 'task partially completed,' and 2 points were assigned to the category of 'task completed.'

In the next step, I excluded the EKS values that appeared before the translations of collocations, which received 0 points from at least one of the experts. These translations were assessed as inaccurate; therefore, I believe they do not reflect the actual cognitive effort. I also decided to exclude from the analysis the EKS preceding translations of collocations that were modified during the translation process, regardless of whether such modifications were implemented in the drafting or the revision phase (Jakobsen 2002). I believe that these EKS values also do not indicate the immediate effort analyzed in this study. Some cognitive processes may still occur in participants' black boxes, leading to further modifications of translations of collocations. There were also cases when a participant translated just one component of a collocation, and the second component was added later in the translation

process. Such EKS values were also not included in the analysis. To sum up, in the case of the L2-L1 translation direction, 170 out of 350 EKS values preceding translations of collocations were excluded from the analysis. In the L1-L2 translation direction, 172 out of 350 EKS values preceding translations of collocations were excluded from further analysis.

6. Results and Discussion

In the first part of this section, I will present the results of descriptive statistics. Next, I will move on to the results of the inferential statistics. Finally, the last part of this section is devoted to a discussion of the results. Statistical analysis presented in this section was conducted using the SPSS program.

The mean values of the EKS indicated some difference between L1-L2 (M= 6591.3ms; SD= 4969.3) and L2-L1 translations (M= 6250.3ms SD= 3238.3). It can be observed that participants produced slightly longer EKS during the L1-L2 translation. A detailed distribution of the mean values of the EKS variable is presented in the histograms in Figure 1 below. Some differences between the two graphs can be observed. There are quantitative differences among the L1-L2 results, with an observable peak of the greatest number of EKS longer than 5000ms. There are also relatively few extreme values and no outliers. A classic normal distribution shape can be observed in the first part of the graph until the moment when the results reach mode. The extremely high results, higher than the mode, are flattened. There are smaller quantitative differences among the L1-L2 results. The graph is more flattened, with a greater number of results that are close to the mode. Another crucial difference is that in contrast to the L2-L1 direction, some outliers in the form of a very long EKS appear in the L1-L2 translation direction. However, as Timarová et al. (2011: 129) pointed out, one should be cautious while analyzing outliers, especially if they are substantially longer than the mean values. Considering memory constraints, such long EKS values may frequently mean data loss of some refixations. In line with the results obtained by Timarová et al. (2011), the results produced by translation trainees are characterized by many fluctuations. Moreover, the histograms indicate that the L1-L2 EKS values are more prone to fluctuations.

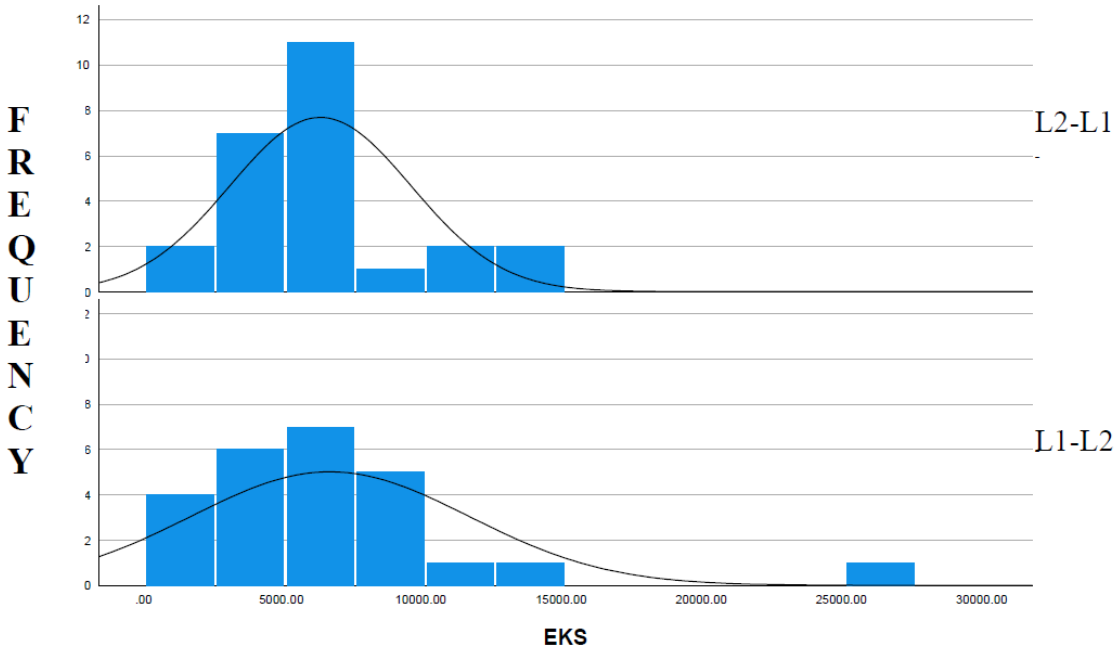

Figure 1. L1-L2 and L2-L1 EKS presented on histograms

For further analysis, I decided to verify the distribution of the EKS in both directions. The results of the Shapiro-Wilk test revealed a lack of normal distribution of the EKS variable both in the L1-L2 and in the L2-L1 translation direction. In the case of the L2-L1 direction $p < 0.001$, and in the L1-L2 translation direction $p = 0.014$. This allowed me to compare the kurtosis and skewness of the EKS results in both directions. The data summarized in Table 3 indicate a leptokurtic distribution in the case of the L1-L2 translation direction. Moreover, regardless of the translation direction, right-skewed histograms can be observed.

Table 3. Kurtosis and skewness

	L1-L2	**L2-L1**
kurtosis	8.9	0.8
skewness	2.6	1.1

Going into detail, the shortest EKS in the case of the L2-L1 translation was 10ms, and it was produced when one of the participants translated the collocation *acoustic information.* The longest EKS in the case of the L2-L1 translation was 85919ms, and it was produced when a

participant translated the collocation *human language*. For the L1-L2 direction of translation, the longest EKS was as long as 103595ms, and it was found before the translation of *odcisk jego łapy*, which was translated as a *footprint*. The shortest EKS in this direction was 66ms, and it was produced when translating *pamiątkowy certyfikat,* which the participant translated just as a *certificate*, omitting its first part, which can be translated as a *commemorative certificate*.

Inferential statistics was conducted to further verify the results. Since there was no normal distribution of the EKS variable, I conducted the nonparametric Wilcoxon test. The result of the test did not reach the level of statistical significance (p= 0.545). As the difference between the L1-L2 and L2-L1 EKS is statistically insignificant, it can be concluded that the L1-L2 translation direction did not require a higher cognitive effort measured in the form of EKS. Thus, the adopted hypothesis was not confirmed.

Because no statistical significance was found, I was interested in whether the results of the statistical test are different when all the EKS values, coming from all 350 translations of 14 collocations in both directions of translation, are included, regardless of the points assigned by the experts, or the moment when the participants typed the translation of collocations. Therefore, I decided to include all EKS values obtained during the experiment to verify the results. This time, the mean values also indicated higher cognitive effort operationalized by longer EKS in the L1-L2 direction of translation (M= 6408.4ms; SD= 3529.3) compared to the L2-L1 direction of translation (M= 6188.9ms; SD= 3543.7). The results of the Wilcoxon test were in line with the previously obtained results. Once again, no statistically significant difference was found (p= 0.81).

It can be observed that the hypothesis adopted in this study assuming that the participants will produce longer EKS in the L1-L2 direction of translation, indicating the increased cognitive effort cannot be confirmed. Although the mean values indicated longer EKS in the L1-L2 direction of translation and some differences could be observed between the histograms in Figure 1, the results did not reach the level of statistical significance. Even though the participants of this study were translation trainees who may be more prone to translation asymmetry (Kroll and Stewart 1994) and problems with L1-L2 translation, the results do not

confirm the view that working into L2 is always more cognitively demanding. It may also mean that the translation process in the L1-L2 direction depends highly on participants' individual preferences and abilities. Since this is the first study devoted to the analysis of the EKS in the context of directionality it is not possible to compare these results with the results from other studies discussing the same topic. However, it is possible to refer to studies discussing directionality based on other eye-tracking and keylogging variables. In line with the study by Whyatt (2019) and Ferreira et al. (2021), the differences between the L1-L2 and L2-L1 translation directions were minimal, and therefore, it cannot be unequivocally stated that working into a foreign language always results in a higher cognitive effort. As Whyatt (2019) and Ferreira et al. (2021) point out, individual differences between the participants may strongly influence such results.

The design of the study may also have some influence on the results. To ensure ecological validity and to avoid the so-called white coat effect, the participants were not informed that the collocations constitute points of interest. Their task was to translate the text they saw on the screen, as they usually do during translation classes or home assignments. Therefore, I am wondering whether the length of the source text and the context surrounding the collocations may cause any interference. While translating longer passages of texts, trainees may take a holistic approach, focusing on the whole text rather than on its parts. They have to remember about the target text coherence, register, and punctuation, and plan their target text ahead. As a result, possible differences between the two directions of translation may not directly translate into significant differences visible in smaller units of meaning, such as collocations. A solution to that may be limiting the context in which EKS is analyzed. This was successfully adopted, for example, in the study by Chmiel et al. (2020), who analyzed EVS and IVS based on single sentences where the points of interest in the form of cognates or non-cognates were placed. Placing points of interest in single sentences or shorter phrases may result in a more precise time-lag measurement, as it will allow participants to focus directly on the analyzed point.

7. Conclusions

This exploratory study aimed to analyze the influence of directionality on cognitive effort operationalized in the EKS, which was measured as a time lag between the last fixation on a collocation in a ST and the moment of typing its translation (Dragsted 2010). Although the mean values indicated that longer EKS are produced during the L1-L2 translation, the Wilcoxon test results did not reach the level of statistical significance. Therefore, it cannot be concluded that the L1-L2 translation direction is directly linked with a higher cognitive effort. It is worth mentioning that this was the first study analyzing EKS in the context of directionality; thus, considerable further investigation is still required. Firstly, its advantage lies in the very high precision of the obtained data. We can analyze very detailed millisecond results related to points of interest and go into detail about the influence of directionality on cognitive effort. Secondly, EKS can also be used to analyze different units of meaning in the context of directionality, such as idioms or metaphors. Thirdly, following the research design of some interpreting studies, EKS can be studied in reference to smaller units like single words or phrases rather than paragraphs or longer text. This may reduce the distracting effect of a surrounding context, making the results of the EKS measure even more precise. Therefore, the EKS values will not be distorted by other elements of the translation process, such as remembering the coherence of the target text and overcoming the interference of the preceding paragraphs. However, this idea is not devoid of obstacles. Reducing the target text length will disenable the analysis of global measures like the number of pauses and total gaze time. Finally, further investigation may also be related to testing whether EKS is a good predictor of other eye-tracking or keylogging measures of cognitive effort and directionality, such as average fixation duration and total gaze time. Linear regression analysis can be used for this purpose. Although the current study concentrates solely on EKS, preventing comparison with other measures, this topic warrants further investigation in subsequent research.

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Appendix

Polish collocations analyzed in the study:

świętować urodziny

przyjść na świat

stracić węch

być ślepym

przynosić komuś jedzenie

kogoś rozpiera energia

skupiać uwagę

zwierze lądowe

przybliżona data

branża turystycza

huczne obchody

limitowana seria

pamiątkowy certyfikat

odcisk łapy

English collocations analyzed in the study:

to provoke a reaction

to make somebody curious

to process information

to analyze intonation

to raise a question

to respond correctly

to develop understanding

a good dog

a high-pitched voice

an acoustic information

spoken words

a brain region

a human language

a common ancestor