

English-Ukrainian translation of synesthetic metaphors: Evidence from keystroke logging and corpus analysis

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Abstract. Linguistic synesthesia is treated as a kind of metaphor occurring in languages commonly and naturally, like any conceptual metaphor. It is a product of mapping between two different domains of human experience, a transfer from one sensory domain (the source) to another sensory domain (the target). Combining the tools of the product- and process-oriented approaches (specifically, the keystroke logging), and the affordances of corpus linguistics, this article examines correlations between the time and cognitive effort spent on choosing a translation equivalent for the source-text synesthetic metaphoric description and its normalized frequency, indicating its degree of conventionality, and showing whether the description rests on broadly shared or linguistically culture-specific cross-sensory mappings. This research utilized the Translog-II software to record and study human translation processes. The log files containing user activity data for translating (reading, writing, and revising) were evaluated, and the results are presented and discussed. The source-text synesthetic metaphoric descriptions that fall into the isolated and marked frequency bands ($NF < 0.1$ occurrences per million words) tend to be either linguistically culture-specific or original. They pose a translation problem, the solution of which requires more cognitive effort and time, more pauses, and more frequent consultations of dictionaries and other online resources to choose the appropriate translation equivalent. The source-text synesthetic metaphoric descriptions with normalized frequency values in the majority, unmarked and dominant bands ($NF \geq 0.30$) are generally not culture-specific and tend to have conventional translation equivalents. In such cases, the choice of translation equivalent and translation procedure is not dictated by linguistic and cultural factors, and it requires less time and cognitive effort.

Keywords: culture-specific descriptions, synesthetic metaphor, Translog-II software, translation studies, GRAC, universal descriptions.

Жулавська Ольга, Мартинюк Алла. Англо-український переклад синестезійних метафор: емпіричні дані методики «Реєстрація натиску клавіатури» та корпусного аналізу.

Анотація. Лінгвістична синестезія розглядається як різновид метафори, що зустрічається в мовах часто і природно, як і будь-яка концептуальна метафора. Вона є

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результатом зіставлення (mapping) двох різних доменів людського досвіду, тобто перенесення з однієї сенсорної сфери (джерела) в іншу сенсорну сферу (ціль). Поеднуючи інструменти продукт- та процес-орієнтованих підходів (зокрема методику «Реєстрація натиску клавіатури») та можливості корпусної лінгвістики, у цій статті досліджуються кореляції між часом і когнітивними зусиллями, витраченим на вибір перекладацького еквіваленту для синестезійної метафоричної дескрипції, вилученої із вихідного тексту, та її нормалізованою частотою, що відображає ступінь її конвенційності та показує, чи ґрунтується опис на універсальних чи мовних культурно-специфічних кроссенсорних відображеннях. У дослідженні використано програмне забезпечення Translog-II для фіксації та вивчення процесів перекладу. Лог-файли (logs), що містили дані про активність учасників під час перекладу (читання, письма та редагування), були проаналізовані, а отримані результати – представлені в статті. Синестезійні метафоричні дескрипції, вилучені із вихідного тексту, які належать до ізольованих і маркованих частотних діапазонів ($NF < 0,1$ на мільйон слововживань), як правило, є або лінгвістично культурно-специфічними, або оригінальними. Вони становлять проблему перекладу, вирішення якої вимагає більше ментальних зусиль перекладача і часу, більшої кількості пауз та частіших консультацій зі словниками та іншими онлайн-ресурсами, для вибору відповідного перекладацького еквівалента. Синестезійні метафоричні дескрипції, вилучені із вихідного тексту, з нормалізованими частотами, що належать до частотного, немаркованого або домінантного діапазону ($NF \geq 0,30$ на мільйон слововживань) загалом не є культурно-специфічними і, як правило, мають усталені перекладацькі відповідники. Вибір перекладацького еквівалента і когнітивної операції не зумовлюються лінгвокультурними чинниками і потребують менше часу та когнітивних зусиль.

Ключові слова: культурно-специфічні дескрипції, синестезійна метафора, програмне забезпечення Translog-II, перекладознавство, ГРАК, культурно-збіжні дескрипції.

Introduction

Research on metaphor translation has always been challenging, marked by extensive discussion and conflict. According to Mandelblit (1995), “the issue of metaphor translation was neglected in the general translation literature because this phenomenon was regarded as an ornament and a figure of speech” (Mandelblit, 1995, pp. 483–495). The situation changed with the emergence of cognitive translation studies (Chesterman, 2009; Risku, 2013, pp. 92–97; Thagard, 2005) influenced by cognitive linguistics and, specifically, by conceptual metaphor theory where metaphor is seen as a product of conceptual mapping that provides an understanding of an abstract entity (the target domain/concept) in terms of a concrete one (the source domain/concept) (Lakoff & Johnson, 1980; Lakoff & Turner, 1989; Gibbs, 1994) and licenses the use of metaphorical linguistic expressions which explain translators’ choices (Kovecses, 2005; Al-Hassnawi, 2007). In addition, the cognitive paradigm has emphasized that “the essential problem posed by metaphor in translation is that different cultures, hence different languages, conceptualize and create symbols in varying ways, and therefore the sense of the metaphor is culture-specific” (Snell-Hornby, 1988, p. 58).

Numerous methods have been applied to investigate the process of metaphor translation. Within the framework of the product-oriented approach, researchers study the product of translators' decisions instantiated in the target-text linguistic expressions and reveal the mappings that underlie the source-text—target-text metaphorical transfer (Al-Harrasi, 2001, 2020; Kovalenko & Martynyuk, 2018; Papadoudi, 2010; Schäffner, 2004; Shuttleworth, 2011). The process-oriented approach focused on the translator rather than the text, aims to discover the algorithms of mental operations that underpin the source-text—target-text metaphorical transfer with the help of think-aloud protocols, eye-tracking, keystroke logging, or EEG measurements of brain activity (Martikainen, 1999; Sjørup, 2008, 2011; Tirkonen-Condid, 2001, 2002). In addition, recent psycholinguistic studies conceptualize translation as a form of bilingual language processing and examine how lexical co-activation, syntactic restructuring, and metacognitive control shape translators' decision-making (Kasap, 2025; Kasap & Işık, 2025). This line of research emphasizes the correlation between declarative and procedural knowledge, inhibitory mechanisms, and structural priming during translation, providing an important theoretical background for the present study, which combines product-based analysis of metaphor renderings with process data obtained through keystroke logging.

The hypothesis of this article is that the translation time correlates with the degree of conventionality (normalized frequency) of source-text synesthetic metaphors and their Ukrainian equivalents: the less conventional the metaphor, the greater the cognitive effort and the longer the processing time required, and conversely, the more conventional the metaphor, the lower the cognitive effort and the shorter the processing time.

The objective of this paper is to investigate how the degree of conventionality of synesthetic metaphoric descriptions (universal or culture-specific) affects the cognitive effort required for their translation from English into Ukrainian. We operationalize conventionality via normalized corpus frequencies (per million words) in COCA and GRAC v.17 and cognitive effort via keystroke-logging measures (translation time, pauses and revisions) in the Translog-II experiment.

The novelty of this research lies not only in the use of keystroke logging or corpus tools, but also in combining them to distinguish how the degree of conventionality of synesthetic metaphors (as captured by the normalized frequency bands) predicts both cognitive effort and the choice of translation procedures in English-Ukrainian translations of metaphors. Based on earlier works on translation of synesthetic metaphors (Duan & Gao, 2014, pp. 290-300; Zhao & Huang, 2015; Yu, 2003; Strik Lievers, 2016, pp. 43-70), our research treats the synesthetic metaphor as a distinct object of translation cognitive analysis and, as far as we know, is the first to examine source-target synesthetic transfer

by means of Translog-II experiment, interpreted within the framework of conceptual metaphor translation theory and corpus linguistics.

The contribution of this study is to link corpus-based frequency bands and process data for a manually extracted set of synesthetic metaphoric descriptions from Antony Doerr's novel *All the Light We Cannot See* (2014), thereby providing empirical criteria for distinguishing universal, culture-specific, and original synesthetic metaphors and for explaining translators' choices between retention, modification, and removal.

Theoretical Background

The phenomenon of synesthesia has been widely investigated in psychology, neuropsychology, the arts, and literary studies. Within the frames of these fields, synesthesia is defined as “a connection of one sensation to another” (Zhao & Huang, 2015, pp. 535–542) or as a “merging of senses” (e.g., sound triggering the experience of color) (Simner & Hubbard, 2013, eds.).

In linguistics, synesthesia is often referred to as a type of metaphor (Williams, 1976; Day, 1996; Strik Lievers, 2016, pp. 43–70) that occurs naturally in languages (Zhao & Huang, 2015; Huang, 2015). Although some researchers argue that synesthesia is a non-typical metaphor (see, for example, Taylor, 2002), relationships of similarity between synesthetic and typical conceptual metaphors are widely recognized by linguists (Zhao & Huang, 2015). We support the metaphorical interpretation of linguistic synesthesia since—like any conceptual metaphor—it is a product of mapping between two different domains of human experience: a transfer from one sensory domain (source) to the other sensory domain (target).

Unlike a typical conceptual metaphor that uses the logic of sensory domains to understand abstract domains (Lakoff & Johnson, 1980; Johnson, 1987; Gibbs, 2006; Kövecses, 2010), a synesthetic metaphor has both the source and the target domains rooted in bodily perceptions of humans. For example, hearing is taste (*he speaks with a high, sweet voice*), hearing is touch (*his voice is low and soft; he laughs softly*), and smell is touch (*a damp, frightening smell*).

Another difference between a conceptual and a synesthetic metaphor is that while the former tends to be culture-specific, the latter tends to be universal, as synesthesia is a universal neuropsychological phenomenon that crosses cultures.

Synesthetic metaphoric descriptions are instantiated mainly by two types of structure: “adjective + noun” or “verb + adverb”, e.g., *soft sound, small voice, cold smell, to speak softly, to look sharply*.

Like any metaphor, synesthetic metaphors can be categorized into the original and conventional types (Strik Lievers, 2016, pp. 43–70). In conventional synesthetic metaphoric descriptions, the meaning of the focal word (adjective or adverb) is adapted to the meaning of the tenor word (noun or verb) (ibid.). Thus, in the examples, *soft sound*, *cold smell*, *to speak softly*, *to look sharply*, the nouns and verbs retain their meanings, while the adjectives and adverbs lose their literal meanings, referring to the touch and temperature domains, and acquire figurative meanings compatible with the linguistic context. As Strik Lievers demonstrates in a corpus-based study of synesthetic adjectives, cross-modal mappings may be conceptually widespread yet lexically and distributionally language-specific, which is highly relevant to our frequency-based analysis of English and Ukrainian data (Strik Lievers, 2016, pp. 43–70). In line with work on cultural variation in metaphorical conceptualization (Kovecses, 2005; Strik Lievers, 2016, pp. 43–70), we treat culture-specificity here in a linguistic sense, referring to language-specific preferences for cross-sensory mappings and lexical realizations. Original synesthetic metaphors represent creative items of thought and language that rest on incongruity, blending elements of the two previously unrelated matrices of thought into a new matrix of meaning (Koestler, 1964) and thus producing a conceptual conflict. As a result, in original synesthetic metaphoric descriptions, the focal and the tenor words preserve their literal meanings (Strik Lievers, 2016, pp. 43–70), e.g., *there was a **loud flash** and a bang*.

Method

Materials

The sample of this research consists of 77 synesthetic metaphoric descriptions from Anthony Doerr's *All the Light We Cannot See* (2014) and their translations into Ukrainian produced by Oleksandra Hordynchuk for the publishing house "Klub simeinoho dosvillia" (Doerr, 2015), as well as the translations of these descriptions by the participants of the Translog-II experiment. The 77 descriptions represent the total number of synesthetic metaphors found in the novel. *All the Light We Cannot See* was published in 2014 and awarded the Pulitzer Prize for Fiction in 2015. The action takes place in occupied France during World War II. A blind French girl, Marie-Laure Leblanc, and an orphaned German boy, Werner Pfennig, whose paths eventually cross, are at the center of the novel. Marie-Laure's father works as a museum locksmith in Paris, and at the onset of the Occupation, they flee to the French countryside, settling in the town of Saint-Malo. Helping her father's uncle, Etienne, and his housekeeper, Madame

Manec, Marie-Laure finds her small role in the Resistance struggle against the Occupation. Werner Pfenning is a bright, inquisitive boy, fascinated with physics and machinery, especially radios. Werner lives with his sister Jutta in an orphanage, listening to the fairy tales told by the orphanage headmistress, and is later selected for the Hitler Youth and trained to give his life to the Fatherland.

Procedure

To handle the data, we take the following steps:

1. Identify equivalents of the 77 English synesthetic metaphoric descriptions in the published version of the Ukrainian translation and construct the cross-sensory mappings underpinning the source-text and target-text descriptions.

2. Reveal the procedures applied by the translator based on Mark Shuttleworth's (2017) classification of translation procedures, which includes *retention* ("translation that is essentially unchanged") (Shuttleworth, 2017, p. 126), *modification* ("indicates the substantial change reflected in a shift of one of the parameters") (ibid.: p. 128), *removal* ("metaphorical expression is replaced by the identifiable non-metaphorical textual material") (ibid.: p. 131) and *omission* ("metaphorical expression is missing from the target text") (ibid.), *addition* ("a metaphorical expression in the target text corresponds to a source text non-metaphor") (ibid.: p. 132). According to the analysis results, out of 77 synesthetic metaphoric descriptions of the source text, 63 were retained, 2 were modified, and 12 were removed from the target text. No synesthetic metaphoric descriptions were omitted or added. To identify addition, we read through the Ukrainian published version of the translation, searching for synesthetic metaphors.

3. Conduct the Translog-II experiment (see below).

4. Compare the procedures applied by the translator of the published version and those applied by the experiment participants.

5. Apply corpus linguistics tools to interpret the results of cognitive translation analysis. We hypothesize that there exists a correlation between the time spent on the source-to-target text transfer, on the one hand, and the degree of conventionality of the source-text synesthetic metaphoric description and its Ukrainian equivalent, on the other hand. To estimate the degree of conventionality of these descriptions, we first compute a *normalized frequency* (per million tokens) for every synesthetic metaphoric description in the *Corpus of Contemporary English* (COCA) and *General Regionally Annotated Corpus of Ukrainian* (GRAC v.17), after lemmatization and disambiguation to exclude literal/irrelevant hits (Biber et al., 1998, pp. 263–264). COCA contains more than one billion words from eight genres: spoken, fiction, popular magazines, newspapers, academic texts, TV and movies' subtitles, blogs, and other web

pages. GRAC has an extensive representative collection of texts in Ukrainian. For the purposes of this study, all corpus searches in both COCA and GRAC v.17 were restricted to the fiction subcorpora to match the genre of our data. Both resources have an installed program that enables searching for words and word combinations, as well as post-processing of the query results. Next, we extract normalized frequency values for each synesthetic description from COCA and GRAC v.17, expressed as occurrences per million words (pmw). We then aggregate these values to obtain the cumulative normalized frequency (CNF) for each cognitive model and sum the CNFs across the relevant baseline set of models (i.e., all competing models within the same paradigm cell). Following Bermel, Knittl and Russell's (2017) proposal, we adopt a seven-band interpretative scale: isolated (0.00–0.01 pmw), marked (0.01–0.09 pmw), minority (0.10–0.29 pmw), equipollent (0.30–0.69 pmw), majority (0.70–0.89 pmw), unmarked (0.90–0.99 pmw), and dominant (≥ 1.00 pmw) (Bermel et al., 2017, pp. 197–231). These bands adapt Bermel et al.'s relative frequency scale to our pre-million frequency values, allowing us to relate corpus frequencies to expected native-speaker acceptability and choice patterns while maintaining comparability across models and languages. Accordingly, synesthetic metaphoric descriptions, whose normalized frequency exceeds 0.30 pmw (i.e., equals or is higher), are treated as conventional, whereas items in the isolated and marked bands (below 0.10 pmw) are treated as low-frequency and thus borderline the original. We hypothesize that, because the original metaphors rest on conceptual conflict and present the author's unique way of thinking, their mappings are not well entrenched in the minds of the source- and target-language speakers and therefore they are difficult to translate as culture- and language-specific descriptions.

Design and Methodology of the Translog-II Experiment

The Translog-II software was introduced and developed at the Copenhagen Business School by researchers supervised by Arnt Jakobsen in 1999 (Karwacka, 2013). The program records and studies human reading and writing processes on a computer. We acquire objective digital data of human translation processes with its help. Translog-II consists of two main components: Translog-II Supervisor, creating a project file and replaying recorded sessions, and Translog-II User running text production experiments (a user reads, writes or translates a text). Translog-II generates log files containing user activity data for the reading, writing, and translation processes, which external tools can evaluate (CRITT@kent, n.d.).

In the experiment, we utilized the Translog-II software to create a project entitled "Translation of synesthetic metaphors", which allowed us to record and

replay the translation process and access the user activity data obtained as a result of the experiment.

The study group consisted of 18 participants: seven were Bachelor's degree students and seven Master's degree students of the Germanic Philology Department of Sumy State University, all specializing in English-Ukrainian translation and having completed several semesters of practical translation courses. One of the key inclusion criteria for student participants was their academic performance, which meant that students who did not attend classes or attended them irregularly were excluded from the experiment. Four were certified, experienced freelance translators of fiction with 5–10 years of professional practice, regularly translating fiction books for Ukrainian publishing houses.

The participants received information about the experiment's objectives, procedures, and estimated duration before the translation session was arranged. The participants received brief training on how to use the Translog-II software. Both students and translators had access to online resources, as well as printed and online dictionaries, during the experiment. The total time spent by the participants on translation ranged from more than three hours (for bachelor students) to an hour and five minutes (for fiction text translators).

The experiment participants were asked to translate 26 sentences containing synesthetic metaphoric descriptions using the Translog-II software. These sentences were singled out from the English sample (77 descriptions) to represent different normalized frequencies. Out of 26 sentences, 11 contain metaphoric descriptions with a low normalized frequency (between .0 and .1), and 9 with a high normalized frequency (higher than 1.0). The normalized frequency of the remaining 6 metaphoric descriptions varies within the range from .1 to 1.0. All relevant data are presented in [Table 1](#).

The participants of the Translog-II experiment observed the translation phases described by Jääskeläinen (1999), Jakobsen (2003), and Englund-Dimitrova (2005). They are preliminary and preparatory phases, including the first draft, revisions, and the final version. The pauses, recorded in the log file, indicated the time spent on planning and problem-solving, that is, finding Ukrainian equivalents of the source synesthetic metaphoric descriptions. The translation choices were classified based on Shuttleworth's list of translation procedures (Shuttleworth, 2017, pp. 125–133).

The Translog-II experiment was followed by a brief questionnaire in which participants indicated the most significant problems encountered during the investigation. The first question was about their general impression of the assignment (positive/negative). The second and third questions asked to choose five sentences that were the most and the least challenging for translation. Questions four and five presupposed selecting the three most and least

complicated synesthetic descriptions in the sentences for translation. All relevant data are presented in [Table 2](#).

Results and Discussion

Translog-II Experiment

This section presents the results of the cognitive translation analysis of sentences containing synesthetic metaphoric descriptions, which were considered the most and the least challenging for translation by the participants in the Translog-II experiment.

In our dataset, highly conventional synesthetic descriptions such as *low voice*, *soft voice* fall into dominant bands ($NF \geq 1.0$ pmw), whereas expressions like *brittle laughter*, *clammy smell* or *damp look* are in the isolated or marked bands ($NF \leq 0.01$ pmw). This frequency contrast is represented in the keystroke-logging data: low-band descriptions tend to require longer translation time, pauses and returns, and are rated as “most challenging” (see [Table 2](#)), while high-band descriptions are translated faster and perceived as “least challenging” (see [Table 2](#)).

Our analysis of the Translog-II logs shows that the total translation time follows a clear expertise distribution: The Bachelor’s degree students spent the longest time on the task (from three to four hours – 7 respondents) and produced, on average, the highest number of pauses and returns to the earlier texts; the Master’s degree students occupy the intermediate position (from two to three hours – 6 respondents), while professional literary translators the task within the shortest time span (from one to two hours – 5 respondents) with fewer pauses and revisions ([Table 3](#)). Notably, one Master’s degree student coped with translation along with professionals in the 1–2 hour band, suggesting an advanced level of knowledge and processing efficiency. These results indicate that it is associated with more efficient processing and more stable drafting, suggesting that greater experience reduces the overall cognitive effort required to handle culturally specific and original synesthetic metaphoric descriptions.

We begin with a translation analysis of the synesthetic metaphoric descriptions that the questionnaire respondents rated as the most challenging ([Table 2](#)).

Thirteen out of eighteen respondents stated that translating synesthetic metaphoric descriptions, such as *brittle laughter*, *feathery voice*, and *clammy smell*, was the most effortful. Let us analyze these translations in detail.

(1) *The air stretches tight; Marie-Laure has the sense that they are watching someone slide onto thin ice or hold a palm over a flame. “What are you saying?” “That we do something.”*

“Put bombs in their shoes?” “Poop in the bread dough?” **Brittle laughter**. “Nothing so bold as all that. But we could do smaller things. Simpler things” (Doerr, 2014).

– Повітря наелектризоване; у Марі-Лор з’являється таке відчуття, наче вони спостерігають, як хтось ковзає по тонкій кризі або тримає долоню над полум’ям. – І до чого ви ведете? – Що ми маємо щось робити. – Підкладати їм бомби в черевіки? – Додавати їм лайно в хліб? **Гіркий сміх**. – Нічого аж такого сміливого. Але ми можемо робити щось дрібне. Щось простіше. [Povitria naelektryzovane; u Mari-Lor z’iavlaietsia take vidchuttia, nache vony sposterihaiut, yak khtos kovzaie po tonkii kryzi abo trymaie doloniu nad polumiam. – I do choho vy vedete? – Shcho my maiemo shchos robyty. – Pidkladaty yim bomby v cherevyky? – Dodavaty yim laino v khlib? **Hirkyi smikh**. – Nichoho azh takoho smilyvoho. Ale my mozhemo robyty shchos dribne. Shchos prostishe.] (Doerr, 2015).

The adjective *brittle* literally means “easily broken, cracked, or snapped” (MWOD; OUP) referring this meaning to the touch domain. In the context of the novel, where it is used to describe the laughter of nervous, tense, and troubled people who gathered to discuss the ways of resistance struggle against the Occupants, the adjective reveals its figurative meaning “unpleasantly hard and sharp and showing signs of instability, nervousness or suffering (about voice)” (MWOD; OUP). As a result, the author creates a synesthetic metaphor that rests on hearing is touch (hearing a suffering voice is touching something brittle) cross-sensory mapping.

Since the direct Ukrainian equivalent of the source-text focal adjective – *крупкий* (“which can easily be crumbled into small pieces” (ADUL)), would sound unnatural in the given context, the translator of the published version of the novel resorted to *contextual substitution* and employed the adjective *гіркий* [bitter], which literally means “having a peculiar pungent, sharp taste” (ADUL), and refers the description to the taste domain. In the context of the novel, the adjective activates its figurative meaning “caused by grief, sorrow, which expresses grief, suffering (about voice)” (ADUL). Thus, using this adjective, the translator applies *modification*: the source-text metaphoric description resting on the hearing is touch cross-sensory mapping is substituted by a description based on the hearing is taste (hearing a suffering voice is tasting a bitter product) cross-sensory mapping.

The Translog-II log files indicate that, on average, participants spent 11 minutes and 12 seconds translating this fragment and produced six pauses during the process (Table 1; Table 3). The participants of the experiment used such variants of translation as *нервовий* [nervous] (removal) and *прохолодний* [cool] (modification – hearing is temperature – this choice is not good, since the adjective *cool* does not render the meaning of suffering, expressed by the source-text description), though most of them employed the adjective *гіркий* [bitter] (Multitran; LinguoLive), which basically reproduces the meaning of the source-

text description, though the image of a voice sounding like a broken, brittle object is lost.

Trying to explain the translators' choice, we assume that modification is dictated by the linguacultural specificity of the cross-sensory mappings. Though the source-text description has a rather low degree of conventionality (its normalized frequency is .07 (COCA)), the conventionality degree of its direct Ukrainian equivalent *крихкий голос* is less than 0.01. This lack of entrenched conventional equivalent creates the translation problem, recorded by the log file (long pauses made by the experiment participants to consult online and paper sources while searching for a suitable equivalent and appropriate translation procedure) (Table 3). To solve the problem, the translators either use a synesthetic description of a higher relevant frequency based on different cross-sensory mapping – *гіркий [bitter] сміх* (.02); *прохолодний [cool] сміх* (.02) or a non-metaphorical expression – *нервовий [nervous] сміх* (Table 1).

(2) One day, Etienne sits with Marie-Laure and reads to her in his **feathery voice**; the next, he suffers from what he calls a headache and sequesters himself inside his study behind a locked door (Doerr, 2014).

– Якогось дня Етьєн запрошує Марі-Лор до себе і читає їй своїм **м'яким голосом**, наступного – страждає буцімто від головного болю й замикається у себе в кабінеті [Yakohos dnia Etien zaproshuie Mari-Lor do sebe i chytaie yii swoim **miakym holosom**, nastupnoho – strazhdaie butsimto vid holovnoho boliu y zamykaietsia u sebe v kabineti] (Doerr, 2015).

The literal meaning of the adjective *feathery* is “resembling, suggesting, or covered with feathers” (MWOD, n.d., OUP, n.d.). Using this adjective to modify the noun *voice*, the author creates a synesthetic metaphoric description *feathery voice* to convey how softly and pleasantly Etienne's voice sounded when reading books to Marie-Laure. In the given context, the adjective loses its literal meaning and acquires a figurative meaning “light, soft and delicate, like a feather” (CFEDT; LODCE) that belongs to the touch domain. The description rests on the hearing is touch (hearing a pleasant voice is touching a feathery surface) cross-sensory mapping.

Since the source-text description cannot be rendered literally (the adjective *пір'яний* (“made of feather” (ADUL)) is not used to characterize voice in Ukrainian (normalized frequency 0.00), the translator of the published Ukrainian version of the book uses the adjective *м'який [soft]* which literally means “not firm or hard to touch, arising the sensation of flexibility at a touch” (ADUL), and thus associates with the touch domain. Employed to describe a human voice, this adjective acquires a figurative meaning of “arising pleasant feelings for hearing; not sharp; quiet, barely audible; kind, heartily, sensitive” (ADUL).

The Translog-II log files indicate that, on average, participants spent 12 minutes and 42 seconds translating this fragment and produced three pauses during this process (Table 1; Table 3). The participants of the experiment gave several variants, among which there were *чаруючий голос* [*fascinating voice*] (removal), *хрипкий голос* [*hoarse voice*] (removal), but the majority used the description *м'який голос* [*soft voice*] (Multitran; LinguoLive; Table 1). Thus, the majority resorted to *contextual substitution* of the focal adjective, which resulted in generalization: the source-text synesthetic metaphor was retained, but its original flavor, brought about by the comparison of a human voice with the touch of a feather, was lost. The translated metaphor is based on a more general cross-sensory mapping of the same domain as the source-text one (hearing is touch (hearing a pleasant voice is touching a soft surface)).

The translation problem recorded in the log and reported by the respondents in the questionnaire is explained by the linguacultural specificity of the source-text's synesthetic metaphoric description. Though its normalized frequency is rather low (.02 (COCA)), the normalized frequency of its direct Ukrainian equivalent is zero (GRAC v.17). In corpus terms, the description *feathery voice* falls into the isolated/marked frequency bands in COCA, and its direct Ukrainian equivalent has no registered hits in GRAC v.17, whereas *м'який голос* [*soft voice*] is considerably more frequent (.34 pmw). This difference in entrenchment helps to explain translators' preference for more conventional Ukrainian descriptions.

(3) Marie-Laure hesitates over the open door, smelling the fires from outside and **the clammy**, almost opposite **smell** washing up from the bottom (Doerr, 2014).

– Марі-Лор вагається над відчиненим люком, вдихаючи запах диму, що долинає з надвору, і майже повну його протилежність – **холодний сморід**, який піднімається з дна [Mari-Lor vahaietsia nad vidchynenym liukom, vdykhaiuchy zapakh dymu, shcho dolynaie znadvoru, i maizhe povnu yoho protylezhnist – **kholodnyi smorid**, yakyi pidnimaetsia z dna] (Doerr, 2015).

The adjective *clammy* means “being damp, soft, sticky, and usually cool; unpleasantly damp and sticky or slimy to touch” (MWOD; OUP), referring the description to the TOUCH domain. The author used the synesthetic metaphoric description *clammy smell* to build up the sensation of war and tragedy, in which Marie-Laure found herself. The war surrounded her, and the only safe place was in the wet, stinky, and disgusting basement. The description rests on the smell is touch (experiencing a disgusting smell is touching sticky / cold / damp surface) cross-sensory mapping.

The translator of the published version of the novel uses the adjective *холодний* [*cold*], which literally means “the one that has low or relatively low temperature” (MWOD; OUP) and associates with the touch/temperature

domain. Employed to modify the noun *smell*, this adjective reveals its figurative meaning “associated with a feeling of inner, emotional coldness, which causes this feeling”. Thus, the translators retained the synesthetic metaphor *smell is touch* (experiencing a disgusting smell is touching cold surface), resorting to the *contextual substitution* of the focal adjectives.

The experiment participants gave several variants of translation of this description. Among them, there were *липкий запах* [*sticky smell*] (retention), and *вологий запах* [*wet smell*] (modification) (Multitran; LinguoLive; Table 1). The most frequently used description was *холодний запах* [*cold smell*] (Table 1) as the experiment participants associated the smell of the basement with the feeling of inner, emotional coldness experienced by the girl.

In this case, the translation problem is caused rather by the originality of the source-text description than its linguistic and cultural specificity. The normalized frequency of the source-text description in COCA is less than 0.01 (COCA), which suggests that its conventionality degree tends to .00, making it rather original than conventional. As with any original expression, the source-text description is unexpected for representatives of both cultures. The Translog-II files indicate that, on average, participants spent 10 minutes 00 seconds translating this fragment and produced six pauses during the process (Table 1; Table 3), which is consistent with the increased cognitive presupposed for low-frequency items. Though it was possible to employ the direct Ukrainian equivalent of the original expression *липкий запах* [*sticky smell*] (and some experiment participants did so), the majority felt safer using a synesthetic description based on a different cross-sensory mapping. The normalized frequencies of all the Ukrainian translation variants are rather low: *вологий запах* [*wet smell*] (.04), *липкий запах* [*sticky smell*] (.01), *холодний запах* [*cold smell*] (.01). The translators’ choices are explained by a low degree of lexical entrenchment and the absence of a strongly conventional equivalent.

Now, let us analyze the translations of the synesthetic metaphoric descriptions *soft voice*, *sweet voice*, and *sharp smell*, which the respondents marked as the easiest to translate.

(4) Etienne talks in his **soft voice** about the eruption of Krakatoa, how, in all of his earliest memories, ash from the East Indies turned the sunsets over Saint-Malo bloodred, big veins of crimson glowing above the sea every evening; and to Marie-Laure, her pockets lined with sand, her face aglow from wind, the occupation seems, for a moment, a thousand miles away (Doerr, 2014).

– Етьєн своїм **тихим голосом** говорить про виверження Кракатау, про те, як у всіх його дитячих спогадах попіл з Ост-Індії зафарбовував сонячні заграви над Сен-Мало в криваво-червоний колір, як великі жили багрянцю щовечора палали над морем. Марі-Лор, у якої повні кишені піску й обвітрене обличчя, на якусь мить окупація здається такою далекою [Etien swoim **tykhym holosom** hovoryt pro

vyverzhennia Krakatau, pro te, yak u vsikh yoho dytiachykh spohadakh popil z Ost-Indii zafarbovuvav soniachni zahravny nad Sen-Malo v kryvavo-chervonyi kolir, yak velyki zhyly bahriantsiu shchovechora palaly nad morem. Mari-Lor, u yakoi povni kysheni pisku y obvitrene oblychchia, na yakus myt okupatsiia zdaietsia takoiu dalekoiu] (Doerr, 2015).

The adjective *soft* literally means “easy to mould, cut, compress, or fold; not hard or firm to the touch” (MWOD; OUP), relating the description to the touch domain. Modifying the noun *voice* with the adjective *soft* Anthony Doerr reveals the figurative meaning of the adjective “(of a voice or sound) quiet and gentle” (MWOD; OUP) and creates a synesthetic metaphoric description, which rests on the hearing is touch (hearing a pleasant voice is touching a soft surface) cross-sensory mapping. According to the context, the description conveys how tender Etienne’s voice sounded when reading books, playing games, or talking to Marie-Laure. He loved the girl very much, and the tone of his voice showed it to the reader.

The translator of the published version of the novel chose the non-metaphorical focal adjective *muxuŭ* [*quiet*] to render the adjective *soft* and thus employed the procedure of *removal*. The Ukrainian adjective *muxuŭ* [*quiet*], describing the voice and sound, means “sounding not loud, full of silence, without loud sounds” (ADUL).

As for the experiment participants, there were such variants of translation as *м’якуŭ* [*soft*] (retention), *ніжний* [*tender*] (removal), but the most frequently used was the adjective *muxuŭ* [*quiet*] (see [Table 1](#)).

The normalized frequency of the analyzed source-text synesthetic description is 2.97 (COCA), indicating a high degree of conventionality. The log file recorded that, on average, the experiment participants took 2 minutes and 42 seconds to complete the translation, with two short pauses noted ([Table 1](#); [Table 3](#)). The respondents stated that the description was one of the easiest to translate. This confirms that in both languages, *low voice* / *soft voice* belongs to the set of highly conventional synesthetic descriptions. It is explained by the fact that in both cultures hearing a pleasant voice is conceptualized as touching a soft surface (see example 2 above). Nevertheless, though in the given context, the meaning of the adjective *soft* is best rendered by its direct non-metaphorical Ukrainian adjective *ніжний* [*tender*], most translators choose another non-metaphorical equivalent *muxuŭ* [*quiet*], which creates a description with a much higher degree of conventionality (normalized frequency is .94 compared to .39) ([Table 1](#)). The translators’ choice is not constrained by linguistic and cultural specificity, but by preferences for more entrenched, high-frequency wording in Ukrainian.

(5) He is undersized and his ears stick out and he speaks with a high, **sweet voice**; the whiteness of his hair stops people in their tracks. Snowy, milky, chalky (Doerr, 2014).

– Він замалий для свого віку, має відстовбурчені вуха, говорить високим, **милиим голосом**, і люди зупиняються подивитися на його біляве волосся – кольору снігу, молока, крейди [Vin zamalyi dlia svoho viku, maie vidstovburcheni vukha, hovoryt vysokym, **mylym holoskom**, i liudy zupyniautsia podyvytysia na yoho biliave volossia – koloru snihu, moloka, kreidy] (Doerr, 2015).

Modifying the noun *voice* with the adjective *sweet* the author creates a synesthetic metaphoric description, which rests on the hearing is taste (hearing a pleasant voice is tasting something sweet) cross-sensory mapping. The literal meaning of the adjective *sweet*, belonging to the taste domain, is “having the pleasant taste characteristic of sugar or honey; not salt, sour, or bitter”, and the figurative meaning related to the hearing domain is “(of sound) melodious or harmonious” (MWOD; OUP). This synesthetic metaphoric description is used to describe Werner. He was too young; his height was insufficient for his age, and his hair was too light and prematurely white. Besides, his voice remained unchanged and still sounded childish.

The translator of the published version of the novel chose the Ukrainian adjective *милуї* [*pleasant*], which is one of the vocabulary equivalents for the source-text adjective *sweet*. Its meaning in terms of sound or hearing is “(about the sounds of voice, laughter, etc.) very nice; causing a feeling of satisfaction” (ADUL). The translated description is non-metaphorical; the translator applied the procedure of *removal*.

The experiment participants used several versions of translation: *солодкий голос* [*sweet voice*] (retention), and *нестлибий голос* [*caressing voice*] (modification – hearing a pleasant voice is experiencing a pleasant touch) (Multitran; LinguoLive; [Table 1](#)), though the most frequently used equivalent was *милуї голос* [*pleasant voice*] (removal) (Multitran; LinguoLive; [Table 1](#)).

The normalized frequency of the original synesthetic metaphoric description *the sweet voice* in COCA is .87 (COCA), indicating a relatively high degree of conventionality. The log file recorded that, on average, translators spent 2 minutes and 48 seconds translating this fragment ([Table 1](#); [Table 3](#)). In only two instances did they pause to consult dictionaries or other online sources to resolve problems related to finding the equivalent and proper translation procedure. This is explained by the fact that in both languages, hearing a pleasant voice is conceptualized in terms of tasting something sweet (the normalized frequency of the Ukrainian description *солодкий голос* [*sweet voice*] is .26). However, most of the translators chose a non-metaphoric description *милуї голос* [*pleasant voice*] (.09). Their choice is not dictated by linguistic and cultural specificity, but by a preference for a more neutral expression in Ukrainian.

The next example presents translations of the synesthetic metaphoric description *the sharp smell*.

(6) It was enough when Werner was a boy, wasn't it? A world of wildflowers blooming up through the shapes of rusty cast-off parts. A world of berries and carrot peels and Frau Elena's fairy tales. Of **the sharp smell** of tar, and trains passing, and bees humming in the window boxes. String and spit and wire and a voice on the radio offering a loom on which to spin his dreams. (Doerr, 2014).

– Цього було досить, коли Вернер був малий, хіба ні? Світу диких квітів, що проростали крізь поіржавілі викинуті деталі. Світу ягід, морквяних шкірок і казок фрау Елени. **Різкого запаху** дьогтю, і швидких потягів, і гудіння бджіл над квітковими горщиками. Дріт, катушка й голос із радіо – веретено, на якому він пряв собі мрії. [Tsoho bulo dosyt, koly Verner buv malyi, khiba ni? Svit dykykh kvitiv, shcho prorostaly kriz poirzhavili vykynuti detali. Svit yahid, morkvianych shkirok i kazok frau Eleny. **Rizkoho zapakhu dohtiu**, i shvydkykh potiahiv, i hudinnia bdzhil nad kvitkovymy horshchykamy. Drit, kotushka y holosiz radio – vereteno, na yakomu vin priav sobi mrii.] (Doerr, 2015)

The adjective *sharp* literally means “having a thin, keen edge or fine point” and “having an edge or point that is able to cut or pierce something” (MWOD; OUP), relating this meaning to the touch domain. The author modified the noun *smell* with the adjective *sharp*, creating a synesthetic metaphoric description *the sharp smell*, which rests on the smell is touch (sensation of unpleasant smell is touching a sharp surface) cross-sensory mapping. In the context of the novel, the adjective reveals its figurative meaning, associated with the smell domain “(of a food, taste, or smell) acidic and intense” (MWOD; OUP). The description is used to convey Werner's speculations about the meaning of life, childhood, and his relationships with his sister. They had happy times in the orphanage, listening to the radio constructed by Werner or to the fairy tales told by the orphanage headmistress, watching the trains passing by, and smelling the scent of flowers and the sharp smell of tar.

The translator of the published version of the novel employed the description *пізкуї запах [acid smell]* (Multitran; LinguoLive). The Ukrainian adjective *пізкуї [acid]* literally means “too strong or bright having an unpleasant effect on the senses” (ADUL). We qualify the procedure applied by the translator as *removal* since the translation equivalent is strongly associated with SMELL and thus loses its metaphorical nature.

The experiment participants gave the variants *зосмпуї запах [sharp smell]* (retention) and *їдкуї запах [pungent smell]* (removal) (Multitran; LinguoLive; [Table 1](#)). The normalized frequency of the source-text description in COCA is .55 (COCA), and it does not present a translation problem because in both languages, the sensation of an unpleasant smell is conceptualized in terms of touching a sharp surface (the normalized frequency of the corresponding

Ukrainian description *zocmpuŭ zanax* [sharp smell] is .39). The Translog-II files indicate that, on average, participants spent 5 minutes and 48 seconds translating this fragment and experienced two pauses during the process, which is consistent with its intermediate conventionality (Table 1; Table 3). However, most translators preferred to use a non-metaphoric description with a higher normalized frequency (the normalized frequency of the description *pizkuŭ zanax* [acrid smell] is .65) (Table 1). Their choice is not dictated by any linguacultural constraints, but rather by a preference for a more conventional, less image-laden way of expressing an unpleasant smell in Ukrainian.

Our findings align with recent psycholinguistic work that conceptualizes translation as a dynamic process shaped by interacting cognitive, linguistic, and sociocultural mechanisms, highlighting the roles of lexical entrenchment and cognitive effort in translation choices (Kasap, 2025; Kasap & Işık, 2025). More specifically, they partially confirm the results reported by Kasap & Işık (2025), as in their study, low-frequency and culture-specific descriptions in Turkish-English translations are associated with increasing processing time, lower accuracy, and the use of compensatory strategies such as circumlocution and L1-based calques, which responds to our keystroke-logging evidence that low-frequency synesthetic descriptions demand greater cognitive effort and are more likely to trigger modified renderings.

Conclusion

The results of the present study lead to the following conclusions. Most of the source-text synesthetic metaphoric descriptions that fall into the isolated or marked frequency bands ($NF < .10$ pmw) pose translation problems: they require more time, trigger more pauses and revisions, and are more often rendered through the cognitive operations of modification and removal. Descriptions, belonging to the majority, unmarked and dominant bands ($NF \geq .30$ pmw) are processed more quickly and tend not to cause noticeable difficulty for translators.

According to our data, low-frequency synesthetic metaphoric descriptions fall into two categories: culture-specific (in a linguistic sense) and original. The first category reflects language-specific preferences for cross-sensory mappings and lexical realizations and lacks well-entrenched conventional equivalents in Ukrainian. These cases constrain translators' choices and prompt modification and non-metaphorical paraphrases. The second category is original, author-specific descriptions, whose mappings are not yet entrenched in either language. They also increase processing time and cognitive effort, but provide translators with greater freedom, as they are not tied to established conventional patterns.

Synesthetic descriptions with normalized frequency values above 0.30 pmw are generally not culture-specific. They tend to have conventional translation equivalents, and the choice of cognitive operations is not driven by linguistic or cultural constraints.

However, even when the underlying cross-sensory mapping is broadly shared within cultures, the lexical and conventional realization of synesthetic metaphors can differ across cultures. Our data confirm Strik Livers' (2016) observation that apparent universality at the conceptual level coexists with language-specific preferences in wording, which helps to explain translators' choices between retention and modification even for similar synesthetic mappings.

As the present research is based on keystroke logging only, we plan to combine in our future research Translog-II with the Think-Aloud Protocol to obtain a richer and more precise picture of the cognitive operations involved in, and the cognitive effort required for, translating synesthetic metaphoric descriptions.

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Olha Zhulavska: Conceptualisation, Software, Validation, Resources, Data Curation, Writing – Original Draft, Visualisation; **Alla Martyniuk:** Methodology, Formal Analysis, Resources, Writing – Reviewing & Editing, Supervision, Project Administration.

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During the preparation of this work the authors used Grammarly, an AI-assisted writing tool, to improve the manuscript's grammar, spelling, and stylistic clarity. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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