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Understanding Emotions When Translating and Reading: a Pilot Study on Dutch-English Proficient Bilinguals

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Abstract:

The present work explores differentiated emotional responses in bilinguals when performing different communicative tasks. Chapter I overviews cognitive aspects of bilingualism and discusses factors impacting our understanding of bilingualism and the categorization of bilinguals. Chapter II reviews emotionality and emotional response, and focuses on its physiological measurement—in particular, electrodermal activity (EDA) and electrocardiogram (ECG)—for emotion recognition. Chapter III reports a methodological pilot study on emotion recognition in Dutch-English proficient bilinguals engaged in reading vs translating neutral vs emotional texts in(to) both their L1 and L2 as measured with both EDA and ECG and self-evaluations. As expected, reading emotional texts in their L1s led to higher physiological arousal than when reading in their L2s. Interestingly, reading of neutral texts in their L2 prompted higher physiological responses than in their L1s. Yet, the most intriguing result concerns task differences: translation tasks yielded the same higher responses than those in reading, when the source text was the same as in reading. Thus, the most interesting hypothesis to be pursued in further studies is that the levels of emotionality when translating are mainly influenced by the source text (and perhaps source language) and not by its target language.

Introduction

Estimating the number of bilinguals in the world is a complex task. More than half of the UN member states have two or more official languages, but many countries officially bilingual, like Canada, do not have a majority of their citizens fluent in both languages. Symmetrically, many countries with a single official language, like Brazil, host significant linguistic minorities, and linguistic diversity can be much higher at the regional or ethnic level. For instance, Cameroon has around 200 languages despite having only French and English as official languages.

Immigrant populations and tourists contribute to bilingualism globally. In Qatar, for example, Arabic is the official language, yet about 1/5 of the population speaks Filipino languages. In Spain the speakers or Arabic (Darija) and Romanian outnumber those of Basque and, in the summer, English is now the third [or perhaps even the second] most spoken language (Muñoz 2011). Furthermore, education systems around the world often teach foreign languages, as seen in Finland, where 60% of adults report speaking English, and many others speak German.

The number of bilinguals worldwide is also difficult to determine accurately due to the blurred lines between languages and dialects and the diverse understandings of bilingualism, ranging from basic conversational ability in a second language to complete fluency, and from passive skills (reading, listening) to a more active communicative engagement (speaking, writing). Anyway, bilingualism is widespread, and it is likely "present in practically every country in the world, in all classes of society, and in all age groups" (Grosjean, 1982: vii). All this reflects a growing recognition of bilingualism as a global norm rather than an exception.

The first chapter of the thesis provides an overview of bilingualism and addresses the main factors used to categorize bilinguals from psycholinguistic perspectives, such as age of acquisition and language proficiency. Particular attention is paid to the bilingual brain and how it works. Moreover, emphasis is placed on the role which the learning context and training play in shaping the bilingual experience, and the fundamental difference between untrained and trained bilinguals and speaking and translating a language is discussed. All bilinguals, regardless of the extent of their active language skills, can engage in translation to some degree (Harris & Sherwood 1978, Whyatt 2017). What bilinguals learn in training is how to translate *professionally,* and the development of professional expertise comes along with higher communicative awareness and metacognitive control.

Research on emotions has also gathered momentum in the last decades, to the point that current times can be considered a *golden age of emotion* (Levenson 2019). Emotional experiences are substantially unique, to the point that attempts to reach a universal definition of *emotion* have been unsuccessful for centuries. The second chapter addresses emotions and their (lack of) definition and categorization. It also focuses on the hypothesized differences in emotionality depending on the language used. Bilinguals often report feeling different levels of emotionality when using different languages, and research has since tried to capture such differences measuring physiological responses. Two main physiological parameters in emotion recognition research, namely electrodermal activity (EDA) and electrocardiogram (ECG) and the way such physiological measurements are applied to research on bilinguals' emotional processing is also discussed. Despite the significant growth in research, there are still factors, variables and aspects to explore on emotional responses in bilinguals. Some relevant gaps in the literature about bilinguals' emotionality are identified in this chapter.

The third chapter presents a methodological proposal to investigate emotional processing in bilinguals when reading and translating in(to) their two languages. Such method, using both introspective (i.e., self-evaluations) and observational measures (i.e., EDA and ECG monitoring), was tested in a pilot study with a limited sample of proficient Dutch-English bilinguals. The phases, design, stimuli, procedures and results of the study are discussed in this chapter.

Chapter I
Bilingualism

Bilingualism is a term of common, but not always well-determined use. For instance, the prefix *bi-* points at the involvement of only *two* languages, yet the word is often used as an umbrella term for *multilingualism*. When looking at *Cambridge Dictionary*, bilingualism is defined as "the fact of using or being able to speak two languages" (Cambridge University Press). This understanding, rather generic and fairly vague, is widely spread and acknowledged, but determining what those 'using' and 'being able to speak' actually stand for is not as easy as it could seem.

1.1 Defining 'first' and 'second language'

Before delving into any other discussion about bilingualism, let us clarify some terminology. The two languages which a bilingual individual is able to use can be referred to as 'first' and 'second language' (also 'L1' and 'L2'). Although 'first' and 'second language' are among the most fundamental concepts of language studies in general, the reality is that there is no single, univocal and universal definition for these terms. Generally, the concept of L1 is also associated with that of 'native language' (which can be described as the language which an individual is born into), while the concept of L2 with that of 'non-native' language (which can be described as a language which an individual is not born into). Though often true, however, it must be kept in mind that this is not always the case, and individuals could also have two native languages.

Different factors can be taken into account when defining L1 and L2. A common distinction between these two terms is made based on time-related dimensions such as: (1) *chronological order of acquisition*, which makes the language that an individual first acquired their L1, and a subsequently added language their L2; (2) *cognitive maturity*, i.e. the individual's level of cognitive development at the moment of acquisition (Hammarberg 2014). As it will also be discussed in the following argumentation, in fact, different ages of acquisition lead to different relationships between language and cognition.

For the purpose of this argumentation and with no further intention of claiming any terminological definition, *L1* will be hereafter understood as the language which an individual first acquired, while *L2* will refer to any additional language which an individual acquired at some later point of their life (regardless of when such acquisition took place) and is able to understand and/or speak to at least a basic extent.

In most cases, in fact, the L1 and L2 do not represent perfectly equivalent dimensions of the bilingual's experience, as factors like proficiency, usage, language skills and so forth have to be taken into consideration. In such cases, the concept of *language dominance* comes into play. Generally, the dominant language can be described as "the language most frequently used by an individual and the one with higher proficiency levels" (Salwei & de Diego 2021, p. 2).

Such language is usually expected to be the individual's first language; however, according to the circumstances which the bilingual individual has experienced and experiences, the dominant language can also happen to be the individual's L2 (when brought by the subject to a level such that the L2 substitutes the L1 in proficiency, usage, skills and so forth). Moreover, the language dominance can vary according to the domain being addressed: for instance, an individual can experience L1 dominance in the family environment and L2 dominance at work, or vice versa (Gottardo & Grant 2008).

1.2 Defining bilinguals

Many variables can influence the outcome of a language acquisition process, and some of them are instrumental in classifying subcategories of bilingualism (Gottardo & Grant 2008). One of such variables, the *age of acquisition* (AoA) distinguishes *simultaneous* from *sequential* bilingualism: the former is deemed to occur when both the first language (L1) and another one (L2) are acquired from birth or prior to the child's first year of age; the latter, instead, occurs when the two languages are acquired in a sequence, i.e., one following another. As it will be discussed later, AoA is believed to be one of the factors which most influence the bilingual experience (see §1.5).

Another distinction which can be made based on AoA is the one between *very early*, *early* and *late* bilinguals. Although these terms are nowadays widely and commonly used in the literature, an exact explanation or definition of what they refer to is often overlooked. Hereafter and for the purpose of this work, 'very early bilinguals' will be considered those who start acquiring both the L1 and L2 at a very early stage of their life (usually before 3 years of age), 'early bilinguals' those who start acquiring the L2 between the age of 3 and that of 6-7 years old, and ‘late bilinguals’ those who start the acquisition from that age on (see §1.5.1).

The reasons behind the acquisition of an L2 let us distinguish *elective* from *circumstantial* bilinguals (Gottardo & Grant 2008). Elective bilinguals, on one hand, choose to learn an L2 in a formal setting (e.g., school) but continue to use their L1 most of the time, and thus their L1 proficiency level remains high. Their L2 simply constitutes a piece of additional knowledge, which is why they are also described as *additive* bilinguals. On the other hand, circumstantial bilinguals *need* to learn an L2 due to the circumstances they are in (e.g., immigrants learning the societal language of the country they now live in). Usually, such individuals end up speaking their L2 most of the time and thus partially or majorly lose or subtract skills from their L1 proficiency. Such phenomenon is labeled *attrition* and also leads to describing these bilinguals as *subtractive*.

Another relevant aspect is represented by the level of language command and dominance, which leads to distinguish *proficient* bilinguals—“individuals who display native proficiency in each language, with minimal interference in speech production in either” (Marcos & Alpert 1976, p. 1275)—from *subordinate bilinguals,* who “show a differential competence in two languages” and use “translation equivalents when speaking in the second language” (Marcos & Alpert 1976, p. 1275).

1.3 A phenomenon of increasing academic interest

Bilingualism has gathered academic momentum especially in the last decades, at least for two reasons. The first one consists in the expansion of bilingualism due to the rampant globalization. Different understandings and approaches to bilingualism make world statistics quite unreliable, but about half of the world population can be considered bilingual (Grosjean 2024). Transnational mobility, the spread of modern technologies and the massive use of English as a lingua franca have certainly fostered this expansion (Cenoz 2013).

The second one consist in the sudden shift in the way in which bilingualism was perceived in the second half of the 20th century. Until the 1960s, bilingualism was thought to slow down children’s development, to the point that it was believed that “the use of a foreign language in the home is one of the chief factors in producing mental retardation”

(Goodenough 1926). Such belief was overcome only in 1962, with the publication of the work that Peal and Lambert conducted in Montreal, where they compared French-English bilingual children to French monolingual ones. The expected outcome would have been for bilingual children to achieve results as good as monolinguals in nonverbal intelligence tests, but lower scores than monolinguals in verbal intelligence ones. However, the bilingual children in the study outperformed their monolingual peers on most tests, leading Peal and Lambert to conclude that bilingualism actually enhanced children's "mental flexibility" and gave them a more diversified set of mental aptitudes compared to monolingual children (Peal & Lambert 1962).

1.4 The 'bilingual advantage' and its consequences for executive functioning

The set of skills in which bilinguals outperform monolinguals is labeled *bilingual advantage* (Bialystok et al. 2003; Van den Noort et al. 2019), but evidence is not overwhelming. On one hand, 28.3% (13) of 46 original studies on bilinguals of any age reviewed by van den Noort et al. (2019) found mixed results about the existence of a bilingual advantage, and 17.4% (8) of them found evidence against it. For instance, bilinguals of any age tend to have a smaller lexicon in each of their languages compared to their monolinguals peers (although the reason for this tendency is yet to be established) (Bialystok 2009).

On the other hand, however, 54.3% (25) of the studies reviewed by van den Noort et al. (2019) did find evidence supporting a bilingual advantage. In particular, bilingualism was shown to enhance executive functioning. Miyake and Friedman (2012) propose that the three primary processes involved in the executive control system consist of updating, shifting and inhibiting: *updating* refers to monitoring and modifying information within the working memory; *shifting* concerns the changes in mental sets; *inhibition* points to suppressing prepotent responses (Bialystok 2009; Zhang 2018).

All three processes greatly concern language management, in particular in bilingual individuals. Earlier research had claimed the existence of a switch in the bilingual mind which activated each time the language relevant to the context (Macnamara & Kushnir 1971), but more recent work shows that both languages remain continuously active in bilingual brains as they process either language (phenomenon described as *joint* *activation*), which entails larger cognitive effort for bilinguals (brain activation in bilingual subjects will be further discussed in §1.5).

1.4.1 Joint activation and cross-language interference

This aspect of bilingualism has been explored in many ways (review in Kroll et al. 2015). A common approach observes how bilinguals process ambiguous lexical items such as cognates (i.e., words that have similar form and meaning across two languages, e.g., *piano* in Spanish and English) and homographs (i.e., words that have similar form but different meaning across two languages[1], e.g., *carpeta*, which in Spanish means 'folder' instead of 'carpet'): bilinguals appear to process cognates faster and homographs slower than unambiguous control words. This suggests that the nontarget language not only is active while the target language is, but also interferes with it both positively (when form and meaning converge) and negatively (when form and meaning diverge) (Kroll et al. 2015).

Some studies exposed bilinguals to stimuli in both languages, thus shedding light on the subjects' behavior when both L1 and L2 were called into play. Other studies, instead, had tasks and stimuli in only one language, to determine whether joint activation also occurs in a monolingual context. Dijkstra & van Hell (2002), for instance, tested subjects with Dutch as L1 who were highly proficient in English. Some of them were also highly proficient in French—at least as proficient as they were in English. The subjects were not aware that the research's focus was on their languages, and their level of proficiency was addressed only after completing the task.

The stimuli presented to the subjects were all in Dutch, but some of them were nonidentical cognates with English—e.g., *bakker*, which is Dutch for the English word *baker*—and others were nonidentical cognates with French—e.g., *feest*, which is Dutch for the French word *fête.* Nonidentical cognates were chosen so as not to create a context of strong language ambiguity, in which a word could belong to any of the languages involved and thus lead to activating the L2.

The word association and lexical decision response times (RTs) in subjects highly proficient in English but relatively low proficient in French were shorter for the Dutch words with English cognates compared to those that were not, but no difference in RTs was detected for Dutch words with French cognates. In contrast, subjects highly proficient

[1] The understanding of 'cognates' and 'homographs' here reported is the one contemplated and referred to by Kroll *et al.* (2015).

in both English and French displayed shorter RTs for all (English and French) cognates compared to noncognates. This suggests not only that the L2 is active at the same time as the L1 and influences the latter at an unconscious level (as in Kroll *et al.* 2015), but also that the effects of cross-language impact on L1 processing come only after a certain level of L2 fluency and proficiency has been attained (Van Hell & Dijkstra 2002).

Joint activation is also present in bilinguals speaking languages whose alphabets or scripts completely differ, as in the case of Russian-English and Chinese-English bilinguals, and even American and British Sign Languages (Kroll et al. 2015; Bialystok 2017). Kroll et al. (2015) also observe that parallel activation happens both at language comprehension and production, and in written, oral or signed form. In brief, potential interference due to joint language activation is an issue bilinguals and multilinguals constantly face. Hence the need for (enhanced) language management cognitive processes.

1.4.2 Cognitive control models of bilingual language processing

At first, researchers focused on identifying a potential one-to-one correspondence between the effects of bilingualism and one cognitive component process (updating, shifting and inhibition). The first studies led researchers to believe that the process primarily influenced by bilingualism was inhibition, because bilinguals outperformed their monolingual peers in tasks requiring them to solve a problem in a misleading context, which was taken to indicate that bilinguals managed to inhibit misleading information to a greater (though not absolute) extent than monolinguals (Bialystok 2001). It was hypothesized that language selection was regulated by a supervisory attentional system (SAS) that helped to inhibit (i.e., suppress) the non-target language to avoid its interference and ensure a contextually and linguistically appropriate performance.

Green (1998) proposed an *Inhibitory Control* (IC) model, based on the assumption that there exist multiple levels of control, one of which involves language task schemas competing to control the output, and claimed that word selection relied on the use of *language tags* (i.e., corresponding representations of a concept in different language systems). Moreover, language control was argued to be *reactive*—that is, the inhibition process would only come into play once the interference caused by the non-target language was detected (Green 1998; Declerck & Koch 2023). The model also implied that an intensive use of inhibitory processes for language selection would end up spilling over inhibitory control for other domains (Green 1998; Bialystok 2017).

Green & Abutalebi (2013) revised Green's IC model in their *Adaptive Control Hypothesis* (ACH), which suggests that the control processes involved in language selection and management adapt to the demands in different interactional contexts. The ACH identified eight cognitive control processes and three different interactional contexts. The eight control processes are goal maintenance, conflict monitoring, interference suppression, salient cue detection, selective response inhibition, task disengagement, task engagement, and opportunistic planning.

The three interactional contexts imposing demands on the above control processes are single and dual language contexts, and dense code–switching. In *single-language contexts* languages are used singularly in distinct environments (e.g., typical diglossic scenarios where one language is used at work and the other is used at home). In *dual-language contexts,* different speakers use both languages; language-switching may occur in the exchange, but not in the same utterance. In *dense code-switching contexts,* both languages are used simultaneously and interactively. Language-switching occurs routinely even within a single utterance, and words are adapted from one language to the other (Green & Abutalebi 2013).

Green and Abutalebi claimed that a single-language context calls for maintenance of the current language goal and avoidance of cross-language interference and associated the suppression of the non-target language with left inferior regions. Similarly, they argued that a dense code-switching context calls for an opportunistic joint activation of languages and associated such adaptive change with circuits in the left frontal and right cerebella. Ultimately, they suggested that a dual-language context calls for a strong suppressive state of the non-target language interference, which however slows down the speed of response to a cue indicating to switch back to that language; this language dilemma was associated with a link between the region responsible for salient cue detection and the ones concerning selective response inhibition, task disengagement and task engagement (Green & Abutalebi 2013).

ACH's distinction between different language contexts also leaves room for the possibility of a *proactive* language control, i.e., an inhibition process implemented ahead, in view of potential cross-language interference (Green & Abutalebi 2013; Declerck & Koch 2023; de Bruin & McGarrigle 2024).

Several further models trying to explain the cognitive mechanisms behind bilingual language processing share the basic theoretical principle of inhibition on which the IC model is also based. That is the case of the *Bilingual Model of Lexical Access,* or

BIMOLA (Grosjean 1997), and the *Bilingual Interactive Activation,* or BIA (Dijkstra & Van Heuven 1998), although one assumes a bottom-up flow of activation, while the other a top-down inhibition process (Green 1998; Li & Farkas 2002). Yet other theories are instead based on Levelt's (1989) production model and therefore do not account for any inhibiting mechanism, but believe that the level of activation of the non-target lemmas influences the target lemma's selection time in accordance with a mathematical rule (Green 1998).

However, the prevailing view seems to be that there is indeed an inhibitory process lying at the heart of language control and bilingual language processing (Declerck & Koch 2023). This will be the line pursued below.

1.5 Cerebral representation of languages: understanding the bilingual brain

The many facets of bilingualism and the many factors influencing each bilingual individual suggest many potential cerebral representations of languages, rather than just one. Several factors contribute to shaping the bilingual experience, and thus the way in which the bilingual brain processes language. Age of acquisition and L2 proficiency are probably among the most relevant factors (Cargnelutti et al. 2019).

1.5.1 Age of acquisition and memory systems

An important concept related to AoA is the *critical period* (Penfield & Roberts 1959; Lenneberg 1967). The *Critical Period Hypothesis* (CPH) for language acquisition hypothesizes the existence of a "critical period" after which learning processes, including language acquisition, become challenging for the individual and ultimately make achieving a nativelike level proficiency in an L2 more unlikely. Initially, such period was thought to extend from infancy to the end of puberty, corresponding to the time frame during which the brain most intensively develops and undergoes maturation; however, Han & Gang (2023) identify three different learning periods: a *critical* period, a *post-critical* or *sensitive* period and an *adult* period.

The *critical period* spans from birth to approximately 6-7 years of age, and in such time very early bilinguals experience maximal neural plasticity, which leads them to ultimately attain an exceptionally high and nativelike L2 command. The *post-critical* or *sensitive period* extends roughly to the end of puberty and witnesses a progressive decline of neural plasticity over time: therefore, increasing AoA results in increasingly non-nativelike ultimate language attainment and increasingly lower language proficiency. During the *adult period*, instead, individuals experience minimal neural plasticity and generally attain lower and asymptotic levels of L2 proficiency; in this case, however, increasingly higher AoA seems not to determine increasingly lower attainment (Cargnelutti et al. 2019; Han & Gang 2023).

Another significant aspect concerning the AoA is represented by the memory systems involved in learning, namely *procedural memory* and *declarative memory*. Such memory systems and their connections to language and communication are discussed by Paradis (2004). Procedural or *implicit* memory refers to the set of an individual's internalized procedures that govern motor and cognitive skills and contributes to the automatic performance of certain tasks. Such system is responsible for implicit linguistic competence, the linguistic knowledge that individuals retain and employ automatically, without being aware of its nature and origin. Implicit memory, more fundamental and pervasive than explicit memory, is the only one observed in infants in their first year of life; after the first 12 months, explicit, declarative memory emerges and continues to develop with age. Declarative memory relates to anything that can be represented at a conscious level, from experiental memory (i.e., knowledge of specific and consciously experienced events) to semantic memory (i.e., general encyclopedic knowledge). From a linguistic point of view, declarative memory is related to metalinguistic knowledge—the individual's conscious, explicit knowledge of the structures, rules and nature of a language. Moreover, declarative memory is very flexible, while procedural memory is inflexible and only available for specific tasks (Paradis 2004).

Clinical, neuropsychological and neuroimaging evidence supports that implicit and explicit memory are dissociated. The involvement of different memory systems according to the learning process through which each language is acquired would explain different consequences concerning language loss and recovery in patients with different pathologies (Paradis 2004). For instance, patients with aphasia present lesions in areas traditionally linked to language processing like Broca's and Wernicke's areas, in parts of the left basal ganglia and the right cerebellum, resulting in damaged procedural memory for language, but spared the declarative one: relying more on the latter than the former, some bilingual aphasic patients end up recovering their (even previously weaker) second language better and to a greater extent than their first. On the other hand, amnesia is linked to lesions in the hippocampal system, including the *parahippocampal gyri* and *medial* *temporal lobes,* resulting in impaired declarative memory and spared procedural one: amnesic patients have been reported to lose their explicitly-learned L2, but retain their implicitly-acquired L1. Similarly, patients with Alzheimer's disease, and so impaired explicit memory, have been reported to lose their L2, while patients with Parkinson's disease, and therefore impaired implicit memory, are more affected in their L1 than their L2 (Fabbro 2001; Paradis 2004; Zanini et al. 2010).

Other clinical evidence has shown that implicit, procedural routines concerning language find representation in subcortical structures, whereas explicit, metalinguistic knowledge is represented in the neocortex (Paradis 2004). Such difference in cerebral representation has been also found with regard to the L1 and L2: when a second language is learned and mainly used by the subject in a formal context, as at school, there seems to be a wider representation of such language in the cerebral cortex; on the other hand, when a language is acquired more informally, as in the case of the L1, the representation tends to involve subcortical structures such as the basal ganglia and the cerebellum (Fabbro 2001).

1.5.2 Brain activations in relation to AoA

Cargnelutti et al.'s (2019) meta-analysis of functional imaging studies reported findings concerning brain activation in early and late proficient bilinguals. The restriction of the analysis to bilinguals showing high proficiency aims at investigating the potential influence of AoA on brain activation independently from any interference in data determined by the non-proficient bilinguals' greater cognitive effort of compensating for their lack of fluency.

In Cargnelutti et al.'s study, both early and late bilinguals seemed to activate mainly their left (dominant) hemisphere, including classical language areas (such as Broca's) and other cortical and subcortical regions seemingly involved with language use and function (such as the left *premotor cortex* and the pre-SMA). In addition, they showed activation clusters in the middle temporal gyrus, responsible for perceiving words over non-linguistic sounds, and the fusiform gyrus, specialized in recognizing written words and contributing to lexical-semantic access.

Brain activation was recorded also in areas related to cognitive control and executive functioning. For instance, the parietal lobe and, in particular, the *posterior parietal cortex* (PPC), was activated in both early and late bilinguals: the activation of such region, normally not relevant to language but to working memory, might suggest a bilingual individual's greater necessity to reinforce and elaborate linguistic information. Another area prominently activated in both groups was the *dorsolateral prefrontal cortex* (DLPFC), traditionally associated with cognitive executive functions and believed to contribute to the inhibition of the interfering language. Similarly, there is evidence of bilateral activation of the insula, usually taken into account as part of the limbic system but also involved in language switching mechanisms (Cargnelutti et al. 2019).

As for the L2, late bilinguals displayed a more substantial network of activations compared to their early counterparts: such network, spanning from the left parietal lobe to frontal regions responsible for language and cognitive control and to the left *superior frontal gyrus,* was found to additionally involve the right cerebellum. Such findings are in line with the belief that L2 requires greater cognitive effort when learned at a later stage.

It is relevant to highlight that both early and late bilinguals showed activation of areas responsible for cognitive control (such as pre-SMA and DLPFC) also when employing their L1, which suggests that each bilingual individual, independently from proficiency or AoA, experiences a constant need for language management and inhibition of the interfering language, even when using their L1 (Cargnelutti et al. 2019).

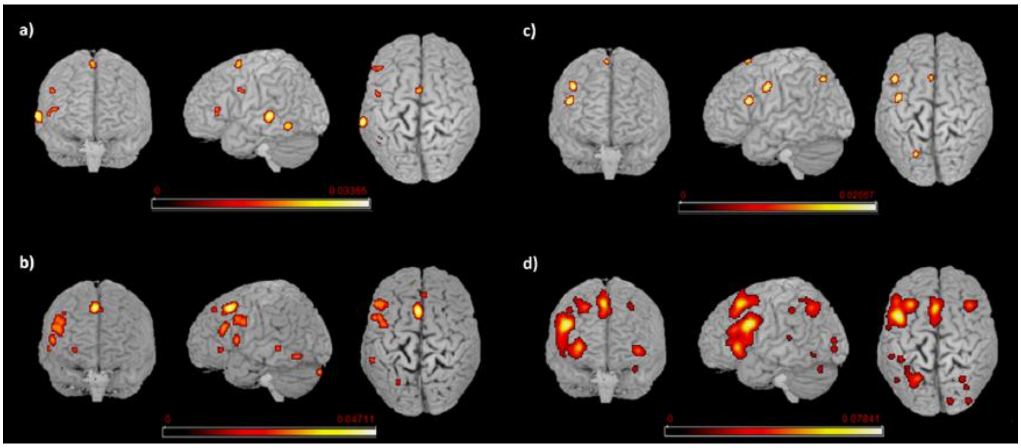

Figure 1. Language networks associated with: **a)** L1 in early bilinguals; **b)** L1 in late bilinguals; **c)** L2 in early bilinguals; **d)** L2 in late bilinguals. Image taken from the study by Cargnelutti et al. (2019).

Mayberry (2007) also conducted a study on deaf children, who have unique language acquisition conditions, investigating whether a delayed general AoA affected the outcome of L2 learning. A group of deaf and hearing subjects had to assess whether a series of sentences (both in English and ASL) were grammatically correct. The subjects who benefited from early language exposure, whether in English or ASL, were found to perform better in many different aspects of language compared to their counterparts who lacked such exposure. Mayberry concluded that a delayed general AoA not only significantly affects the outcome of L1 acquisition, but also compromises the individuals' learning and acquisition of all subsequently learned languages.

1.5.3 Brain activations in relation to proficiency

Several studies have addressed the role of language proficiency in functional activations in the bilingual brain. Some argue that such role is not very significant, but evidence supports that indeed proficiency affects cerebral representations.

Perani et al. (1996, 1998) compare the patterns of activation in *high* and *low proficiency late bilinguals* (HPLA and LPLA) who listened to stories in both their L1 and L2. The patterns of activation in HPLAs and LPLAs were similar in their L1, with foci in the left temporal pole, the middle temporal gyrus and hippocampal structures. In L2, however, only the HPLA group displayed a left hemisphere's activation pattern similar to that observed with their L1. The LPLAs showed no activation of the temporal poles or the left anterior and posterior part of the middle temporal gyrus (Perani et al. 1998).

Stein et al. (2009) employed fMRI to observe proficiency's influence on brain activation during lexico-semantic processing of L1 and L2 words: English L1 speakers studying German were examined at the beginning and at the end of an immersive language-learning period of five months in Switzerland. They hypothesized that (a) with increasing L2 proficiency comes the ability to process and access language in a way which resembles more and more the processing of L1; and that (b) low proficiency calls for stronger reliance on strategic control and, therefore, implies greater frontal activation, which should decrease once proficiency increases (Stein et al. 2009).

They found support for both hypotheses. At the beginning of the study, activation related to lexico-semantic processing was stronger with L2 than with L1 in four areas: the right *inferior frontal gyrus* (IFG), the left IFG, the left *inferior frontal sulcus* and the left *supplementary motor area*. At the end of their 5-month immersion stay for intensive German learning, the subjects' L2 proficiency had significantly increased, and only the left inferior frontal sulcus still showed significant activation while processing the L2 (and yet reduced in comparison with activation at the beginning of the study). Furthermore, activation in the frontal lobes—believed to act as a semantic executive system and control semantic retrieval—decreased with increased proficiency (Stein et al. 2009).

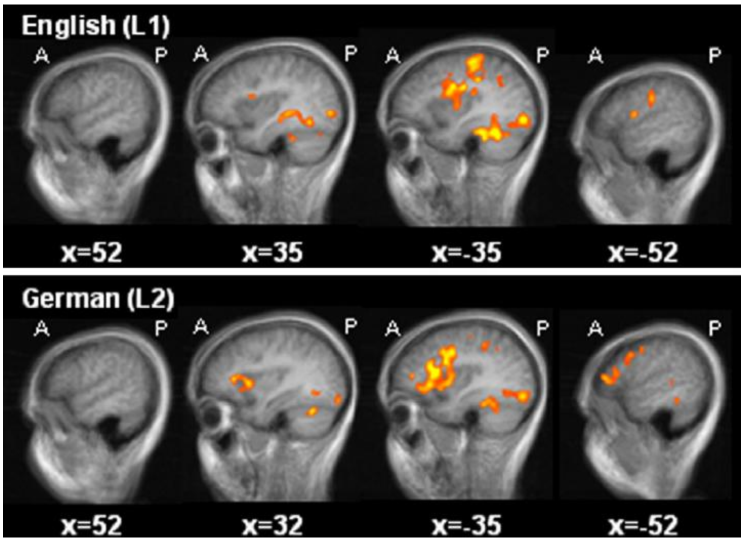

Figure 2. Brain activation during the lexico-semantic task. Top row: English words vs. nonevents; bottom row: German words vs. nonevents. Data collected at the beginning and at the end of the learning period was pooled for this display. Image from Stein et al. (2019).

Yet the degree to which AoA and language proficiency influence neural networks and representations associated with bilingualism still remains a topic of discussion. Some studies find that L1 and L2 neural networks are similar in early bilinguals and different in late bilinguals, but Ou et al. (2020) hypothesize that early bilinguals' L2 early acquisition leads them to develop different, language-specific neural plasticity for each of the languages, while late bilinguals rely on the neural system employed for the L1 when they process their L2.

1.5.4 Interaction between AoA and proficiency

In any case, it is widely assumed that AoA and language proficiency are closely related. In particular, individuals with an early AoA ultimately attain higher levels of L2 proficiency compared to those who acquire the language later in their life. For this reason, it is difficult to disentangle these two variables to observe their effects and consequences separately. Oh et al. (2019) suggest that both AoA and proficiency affect neural activation, but independently, and studied such matter by keeping one variable constant in order to obtain results that depend on the other variable. They divided their bilingual participants into three groups, namely (1) *early acquisition* + *high proficiency,* EAHP; (2) *late acquisition* + *high proficiency,* LAHP; and (3) *late acquisition* + *low proficiency,* LALP. The cut-off age to distinguish between early and late bilinguals was 7 years of age.

While lying in an MRI scanner, participants had to first think about, then say aloud the (regular or irregular) past tense of a verb which they were presented with in the present tense. Compared to early bilinguals, late bilinguals showed greater activation across both hemispheres when processing all past tenses. Two reasons may be considered accountable for this phenomenon: the first one consists in automaticity, which is generally associated with reduced activity in the inferior frontal cortices and right *middle frontal gyrus* (where early bilinguals showed less activation); the second one consists in the changes in neural plasticity which affect language learning and have been discussed above.

Activation in the left IFG was observed in both early and late bilinguals when producing regular past tenses, but only late bilinguals would display such activation with irregular past tenses. A pattern of activation similar to that of early bilinguals in this study had been previously found by Oh et al. (2011) in monolingual native English speakers carrying out the same task. This suggests that early bilinguals perform *selective activation,* which depends on the specific type of task which they are engaging in (computational process for regular inflection, lexical retrieval for irregular inflection). Such hypothesis, consistent with the concept of declarative and procedural memory, would indicate that early bilinguals acquire L2 grammar elements in the same way L1 speakers do (Oh et al. 2019).

As for L2 proficiency, Oh et al. (2019) found that it also affects neural activation, independently from AoA. Within late acquisition participants, highly proficient speakers (LAHP) displayed overall greater activation than their less proficient (LALP) counterparts, with higher activation of the right frontal areas when processing regular past tenses and increased bilateral activation when processing irregular ones. Greater activation was also detected in the right *inferior parietal lobe* for LAHP bilinguals, compared to LALP ones.

LAHP bilinguals displayed greater brain activation compared to both EAHP bilinguals (those with different L2 AoA) and LALP bilinguals (those with different L2 proficiency). Oh et al. (2019) proposed two explanations for the less extensive brain activation recorded in EAHP and LALP participants: decreased activation might result from increased language automaticity and, therefore, reduced neural effort; this would explain differences between LAHP and EAHP bilinguals. Lower activation in LALP bilinguals could be explained as a potential lack or inadequate engagement in the task, due to perceiving it as too complex.

1.5.5 Neuroplasticity and structural changes

The summarized evidence points to a very close connection between bilingualism and neural plasticity. Many activities are generally agreed to bring about neuroplastic benefits, such as musical training and performance, videogame playing and juggling. None of them, however, are as impactful as bilingualism can be (Bialystok et al. 2012; Bialystok 2017).

Regardless of how intensively these other activities are practiced, they can only be undertaken for a certain number of hours per day. In contrast, language use permeates every aspect of human activities and is instrumental for most of them, at least while awake. Furthermore, using language involves a very significant brain engagement, with contributions from the temporal, parietal and frontal lobes, and even some posterior regions (Bialystok et al. 2012). Therefore, bilingualism is positively correlated to that “ability of the nervous system to change its activity in response to intrinsic or extrinsic stimuli by reorganizing its structure, functions, or connections” (Mateos & Rodríguez 2019) just as much as the other aforementioned activities, if not even more.

Li et al. (2014) review studies looking at anatomical brain features and conclude that bilingualism correlates to increased *grey matter* (GM) density and *white matter* (WM) integrity at all ages, and that even short-term learning or training can induce such brain changes. For instance, Mechelli et al. (2004) found greater GM density in the (especially left) *inferior parietal cortex* in bilinguals compared to monolinguals and, within bilinguals, in early bilinguals compared to late ones. Moreover, GM density positively correlated to L2 proficiency (the higher the proficiency, the higher the GM density) and negatively correlated to age of acquisition (the higher the age of acquisition, the lower the GM density).

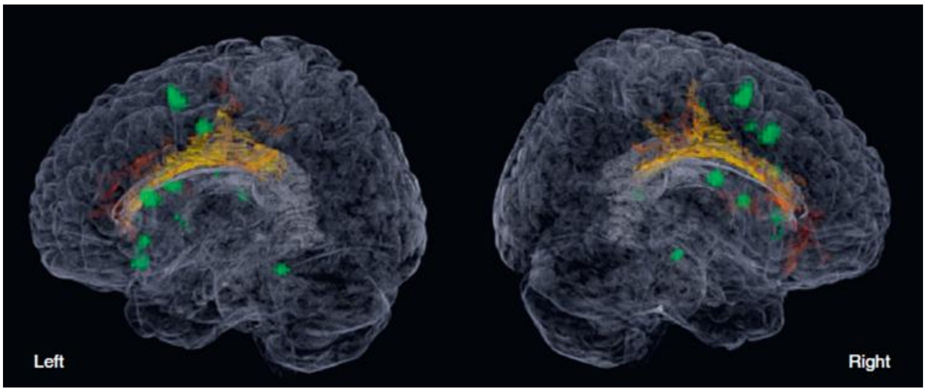

Figure 3. Green areas indicate grey matter regions with high activation during bilingual language switching, while red and yellow areas indicate regions with higher white matter integrity in bilingual adults, compared to monolinguals. Image from Bialystok et al. (2012).

1.6 Bilingualism and language training

In more recent times, bilinguals are also being subcategorized as *trained* vs. *untrained.* The expression 'trained bilinguals' is generally used to refer to translators, interpreters and language professionals such as technical writers who have received specific language education and training (e.g. in linguistics, translation, interpreting, communication), while 'untrained bilinguals' are those individuals who do in fact know and use more than one language, but learned it in a less formal way and not through specific education aimed at making them obtain fine-tuned linguistic knowledge.

1.6.1 Formal, informal and non-formal learning

Coombs & Ahmed (1974) distinguished between three types of learning: *formal*, *nonformal* and *informal*. In Coombs & Ahmed's work, *formal learning* was defined as the one happening in "the highly institutionalized, chronologically graded and hierarchically structured 'education system'" (Coombs & Ahmed 1974, p. 8); *nonformal* education was referred to as "any organized, systematic, educational activity carried on outside the framework of the formal system to provide selected types of learning to particular subgroups in the population" (Coombs & Ahmed 1974, p. 8); *informal* education was pointed out as "the lifelong process by which every person acquires and accumulates knowledge, skills, attitudes and insights from daily experiences and exposure to the environment" (Coombs & Ahmed 1974, p. 8).

These forms of learning exhibit significant differences (review in Johnson & Majewska 2022) summarized in Figure 4. On one hand, formal and nonformal learning may be structured and based on a predetermined curriculum, may take place in educational institutions and be formally assessed. Formal and nonformal learning are usually intended and consciously recognized by (at least) the learner; informal learning, instead, does not follow a specific structure or curriculum, is generally not formally assessed, can take place anywhere and is not always intended or consciously recognized by the learner.

On the other hand, nonformal and informal learning involve a greater focus on the needs of the individual learner, rely on procedural, rather than propositional (i.e., declarative) knowledge, and involve cognitive, emotional, social and behavioural elements, while formal learning aims at acquiring a specific set of skills and notions, focuses mainly on propositional knowledge and puts emphasis on cognitive elements, rather than emotional, social and behavioural ones (Johnson & Majewska 2022).

Formal learning	Non-formal learning	Informal learning
Learning is structured (e.g., linear learning objectives)	Learning may be structured	Learning is not structured
Learning is promoted through direct teaching behaviours	Learning is promoted through indirect teaching behaviours	
Learning is intended (by educator and learner)	Learning is intended by the learner	Learning may not be intended by the learner
Learning is recognised by the learner and educator	Learning is recognised by the learner	Learning may not be recognised by the learner
Motivation for learning may be extrinsic to the learner		Motivation for learning is intrinsic to the learner
Learning takes place in educational institutions	Learning can take place in educational institutions	Learning can take place anywhere
Learning has a mandated dimension	Learning has a voluntary dimension	
Learning may be recognised or measured through qualifications		Learning is not recognised or measured through qualifications
Learning may primarily focus on propositional knowledge	Learning may focus on both propositional and procedural knowledge[11]	
Learning tends to have a cognitive emphasis	Learning involves cognitive, emotional, social and behavioural elements	
Curriculum is written down	Curriculum may be written down	Curriculum is not written down
Learning process is 'top down', focusing on developing specific knowledge and skills	Learning process is 'bottom up', focusing on the learner and their needs	
Learning follows formal curriculum	Learning may complement formal curricula	
Learning may not be linked to socialisation[12]		Learning is often linked to socialisation

Figure 4. Comparison between the characteristics of formal, nonformal and informal education. Image taken from the report by Johnson and Majewska (2022). Reproduced with permission.

1.6.2. Advantages and disadvantages of the different types of learning

As can be expected, each type of learning comes with its benefits and drawbacks. Standardized curricula, typical of formal learning, can be considered effective tools to ensure equal skills and information attainment across society. Curricula are usually designed so as to provide generalizable knowledge that is applicable in different contexts and domains. Such a highly organized and structured educational approach runs the risk of being perceived as excessively inflexible and restrictive for both the educators (who may feel their ability limited to adopt alternative and personalized methods) and the learners, who may feel demotivated and discouraged by a learning program that does not reflect their own pace and needs (Johnson & Majewska 2022).

The more contextual learning dimension of nonformal learning minimizes such risk by resulting more motivating and engaging to the learner, who is thus more likely to succeed and feel like the program better aligns with their learning pace and needs; moreover, nonformal learning has more impact than formal learning at affective, social and behavioural levels: the contextualization of the learning process encourages the learner to develop a series of skills (e.g., communication, social and organizational ones), which are fundamental for a better application of the knowledge acquired. However, a twofold concern may be associated to nonformal learning: for nonformal programs based on a structured curriculum, the same negative observations concerning formal education can be raised; in less-structured nonformal program, worries arise about the effectiveness and reliability of its outcomes.

Given the equally experiential dimension, informal education shares many of the advantages and disadvantages of nonformal learning, such as the enhanced development of a specific set of skills, the learner's higher engagement and motivation and the concerns regarding the learning outcomes and acquired knowledge, which risks being too context-specific and not transferable or generalizable enough. In addition, whilst the higher likelihood of unawareness of the learning process involved in informal education makes the attainment easier for some learners struggling with structured formal education, it also makes it more difficult to recognize whether and how the learning is taking place.

1.6.3 Early bilinguals vs. translators: 'untrained' and 'trained' bilinguals

L2 proficient speakers should not be considered equal regardless of their circumstances, motivations and ways of language acquisition. This widespread misconception ignores the fact that different types of learning have different inherent features and can yield different outcomes, depending also on the individual undergoing the process. Language learning is no exception.

Some individuals acquire one or more L2s spontaneously—sometimes, even unconsciously—as a result of the circumstances in which they are brought up (and thus are *circumstantial* bilinguals, see §1.1): it is the case of *early bilinguals*, who are exposed to two languages since early in their lives and tend to develop a high proficiency in both of them. Usually, this happens when the language spoken in the family environment differs from the one generally spoken in the place where the child grows up (e.g., second-generation immigrants who speak one language at home and another one at school and with their friends). In this manner, children learn both languages mostly informally and out of necessity and associate them with emotional and social aspects of their lives. They are thus *untrained bilinguals*, as their linguistic skills come mainly from unprofessional experiences rather than from professional training.

On the other hand, there are individuals who decide to learn a language in a subsequent moment of their life, out of personal interest, convenience or career choice, and generally follow a series of courses in order to do so (and thus represent *elective* bilinguals, see §1.1). This is often, for instance, the case of *professional translators*: although they may have some previous knowledge of the language which they want to specialize in, such language usually represents for them a subsequently learned L2, although also many early bilinguals pursue a career in communication. Most importantly, however, all such individuals generally undergo specific training courses (e.g., Bachelor of Arts, Master of Arts, specialization courses, etc.) in order to learn how to translate textual material in both languages properly, which is why they can be considered and referred to as *trained bilinguals*.

1.6.4 Distinguishing speaking and translating a language

Laypersons often think of languages as bags of words that categorize reality, and translating is then erroneously considered to be only a verbatim (i.e., literal, word-for-word) transposition of a text from one language into another. Translating, however, whether professional or not, actually "involves linguistic analysis and comprehension of the SL [Source Language] in order to construct a mental representation of the message and planning and lexical selection processes in order to produce the target message" (Tzou et al. 2017).

It is interesting to look at disorders encountered in bilingual aphasic patients which concern translation capabilities and show that translating is a different skill from mastering an L2, such as *inability to translate* (in either or both the translation directions), *spontaneous translation* (a need felt by the patient to translate everything that is being produced by either themselves or the interlocutors), *translation without comprehension* (the patient is able to translate sentences in a certain language, but not to understand them or their meaning) and *paradoxical translation* (the patient can translate only into a language which they cannot speak spontaneously, but not into a language which they can speak spontaneously) (Green 1998; Fabbro 2001). These conditions prove that speaking and translating are cognitively different.

The case of paradoxical translation—the possibility that a patient's ability to translate can be compromised more or less temporarily in only one of the individual's linguistic directions, while the other remains unaffected—also suggests that translation directions represent neurofunctionally separate components acting independently from each other, which Paradis (1984) identified as: (1) one responsible for translating from language A into language B and (2) one responsible for translating from language B into language A (Fabbro 2001).

As translation does not represent a mechanical, verbatim transposition of a text from one language into another, the possible translation outcomes are as many as the individuals carrying out the translation. Whether consciously or not, each translator—here intended as any subject engaged in a translation task—employs a certain strategy and makes a series of decisions based on his (unique) experience: therefore, the differences in translation outcomes.

Tzou et al. (2017) conducted a study based on the translation of idiomatic expressions to investigate whether individuals with formal training in translation/interpreting (i.e., trained bilinguals) employ a different strategy compared to individuals without any formal training (i.e., untrained bilinguals), and, therefore, whether translation training has any influence on the choice of the strategy to employ or implies any advantage for the trainees (referred to by the authors as 'translation-training advantage').

The results showed that, although both trained and untrained bilinguals were faster in reading the idiomatic expressions in their L1 compared to their L2 and almost equally accurate in recognizing when a translation was the correct rendition of a certain idiomatic expression in the other language, trained bilinguals were significantly more accurate in recognizing when a translation was *not* the correct rendition (Tzou et al. 2017), an ability of all but irrelevant nature for the purpose of an accurate, reliable translation. Although there may be alternative explanations to these findings, the formal training in translation is a fair one to take into consideration.

1.6.5 Perception, culture and the implications for translators

As swiftly mentioned before, all human experience is unique. That is because all human experience, learning included, is based on perception, and not all human beings perceive the world in the same way. Taking into consideration sight, for instance, one can already think about several different variations of perceptual capabilities, such as refractive errors and blindness. What the human body perceives at a physical level, however, does not in itself constitute the entirety of the perceptual experience: the brain, in fact, is responsible for interpreting these signals (Tymoczko 2012).

It is significant to highlight that the use of *interpreting* rather than *processing* is not unfounded. Factors like context and culture strongly influence and shape the way in which individuals perceived the world. Pevtzow & Goldstone (1994) showed that people tended to decompose a given object in different ways depending on which component parts they had gained experience with, thus supporting the hypothesis that the way in which we see the world highly depends on our experience of it.

The same holds true for language: infants up to four months of age are able to perceive the phoneme contrasts of any language in the world, but lose such ability and see it restricted only to their own language by the end of their first year, as they start to discern which elements are relevant to their reality and which are not (Ellis 2006; Tymoczko 2012). Other dimensions of individual experience are (mostly unconsciously) shaped by the cultural framework we are immerged in, such as the set of values we embrace, our ethical perspectives and the emotional legacies we carry (Tymoczko 2012).

L2 learners cannot be considered a *tabula rasa* even when they start language acquisition from zero, for their brain structure and functions have already been influenced by their L1, and their original maximal neural plasticity cannot be fully restored (Ellis 2006). Similarly, their cultural background and the ways in which it impacts their perception of the world cannot be fully reset to embrace the new set of cultural connotations as it would have had if they started at birth.

The implications for translators are many. During their professional training, translators are taught to carry out translations aiming to recreate on the target audience the effect that the source text produces on speakers of that language. Considering what has just been discussed, however, it is only logical to deduce that a non-native speaker (i.e., the translator) will always perceive a given text in their L2 (i.e., the source text) in a way which is fundamentally different from the one in which that same text will be perceived by a native speaker of that language. Therefore, it can be argued that a translator will never be able to translate a text from their L2 into their L1 while reproducing in the target text the same effect intended for the source target audience, as they *themselves* never perceive it that way. At the same time, they receive specific training (very often provided by L1 speakers of their L2, who then have a 'nativelike perception') in order to learn how to complete such task. The wonder, then, is whether this component of their training is enough to compensate for the translators' lack of such nativelike perception or if the "cultural bias" in interpreting a text cannot be overcome.

A logical argumentation and conclusion could be that early bilinguals, who were exposed to both the languages and the respective cultural frameworks since a very young age and (most probably) in contexts that allowed for the development of a nativelike perception, represent a better and more reliable alternative to translators to achieve the much strived *source effect reproduction.* However, the lack of professional training for these subjects suggests that they will likely overlook or fail to detect a variety of crucial, albeit not immediately apparent, factors which contribute to the achievement of an effective, reliable translation. Thus, it can be argued that, even if they met the requirement of nativelike perception, the translations performed by these untrained bilinguals may diverge in a whole range of other elements.

Chapter II
Emotions

The term *emotion* and the ideas behind it have had a surprisingly short life. Imported into English in the 17th century, the French word *émotion* was originally used to denote a physical disturbance or bodily movement. During the 18th century the term slowly begun to be used to refer to bodily movements that accompany mental feelings. Only in the 19th century, thanks to the Scottish philosopher Thomas Brown (1820/2010), *emotion* definitively became a theoretical term to indicate vivid mental feelings.

Brown claimed that *emotion,* though shared and easily understandable by everybody, was actually extremely hard to define. Indeed, many definitions exist nowadays, and so it seems that Brown's assessment is still true (Dixon 2012). A recurrent argument in the literature, with seemingly less intense debate, concerns what emotion is *not*.

Emotion is often distinguished from another affective component, *mood*. Emotions seem to point to states that are higher in intensity, shorter in duration, and stronger as to the physiological arousal they prompt. That is, moods are milder and longer affective states with softer physiological impacts (Allen 2005). *Object-directedness* has also been argued to tell them apart: emotions are seen as directed to a specific object—e.g., anger cannot exist without something to be directed to— while moods appear not to be object-directed (Allen 2005).

2.1 Classification

Research on emotions often uses taxonomies to detect and categorize them. Generally speaking, such taxonomies are either *categorical* or *dimensional*. Categorical taxonomies typically identify and label four, six or eight basic emotions or clusters of emotions as discrete categories. Such taxonomic categories can be generic or domain-specific—e.g., *boredom* and *confusion* for academic contexts (Sreeja & Mahalakshmi 2017; Nandwani & Verma 2021). Ekman and Friesen investigated emotions and facial recognition in both literate and preliterate cultures across the globe and postulated six basic emotions they considered universal: happiness, sadness, anger, surprise, disgust, and fear (Ekman 1971; Ekman & Friesen 1971). A slight difficulty in differentiating between fear and surprise suggested that "cultures may not make *all* of the same distinctions among emotions, but

[this] does not detract from the main finding that most of the distinctions were made across cultures" (Ekman & Friesen 1971, p. 128). Categorical taxonomies allow for automatic categorization with distinct labels that are easy to understand and recognize. Yet, they may fail to capture emotional nuances and result in non-optimal emotion detection (Sreeja & Mahalakshmi 2017).

Dimensional taxonomies, instead, inscribe emotions within a two- or three-dimensional space. Two-dimensional models consider two variables. An instance of such variables are *valence* and *arousal*: *valence* refers to the degree of pleasantness of the feeling (from unpleasant to pleasant). *Arousal* denotes the degree of excitement elicited in the individual (from passive to active). An instance of dimensional model is Russell's (1980) *circumplex model of affect,* which organizes emotions in a circle and attributes them numerical values depending on their location in his two-dimensional space (valence-arousal).

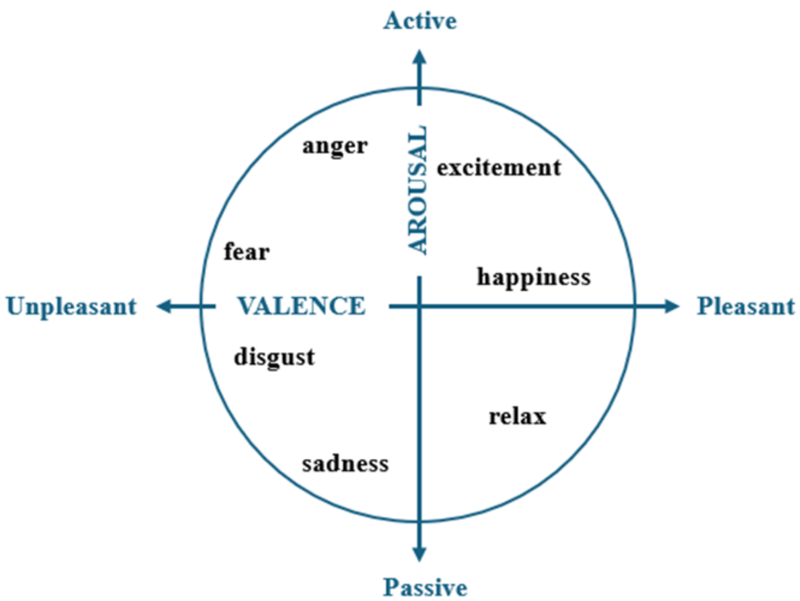

Figure 5. Instance of a two-dimensional space for emotions based on valence and arousal. Image adapted from Egger et al. (2019).

Two-dimensional models can also be based on other criteria, such as Plutchik's (1980) emotion space defined by *activation* and *evaluation*, and Thayer's (1990) dimensions of *energy* and *stress*. Nonetheless, the dimensions of valence and arousal are very commonly used to denote emotions. On the other hand, three-dimensional models also add *power*. *Power* defines the degree of sense of control over the emotion (Sreeja & Mahalakshmi 2017; Mavrou et al. 2023). Labels may be model–specific: for instance, valence can be referred to as *polarity* and power as *dominance*; also, arousal can be measured in terms of ranges from *boredom* to *wild excitement* (Sreeja & Mahalakshmi 2017). The basic concepts, however, remain fairly consistent across the models.

2.2 Emotional processing in bilinguals

Emotional processing is a fundamental aspect of the human experience, witnessing the vast literature on the subject, deeply rooted in the history of psychological research. At the crossroads of such investigations and those on languages there emerges bilingualism and a puzzling phenomenon (Sharif & Mahmood 2023; Aguilar et al. 2024): emotions may be different depending on the language spoken. Furthermore, monolinguals' and bilinguals' experiences of emotional processing may be substantially different.

2.2.1 Languages and differentiated emotionality

Already in the second half of the 20th century, research in bilingual psychotherapy reported that most bilinguals tend to either express (in self-reports) or exhibit (in experimental settings) higher levels of emotionality in their L1 than in their L2 (Harris et al. 2006). While investigating *subordinate* bilinguals (i.e., those showing a marked difference in proficiency between the two languages), Marcos (1976) noticed an evident emotional detachment when the subjects were speaking the language in which they were less proficient; as a reason behind this, he hypothesized that encoding information in L2 required from the subjects a much greater effort compared to that in their L1.

Several studies reported evidence in support of this hypothesis. In Buxbaum (1949, in Javier 1989), a German-English bilingual patient appeared to verbalize different streams of associations depending on the language at issue (the English *sausage* compared to the German *blutwurst*), with the recall of memories related to infantile sexual material coming up only when speaking in the primary language. Javier (1989) reported on a Spanish-English bilingual woman who had difficulties in speaking Spanish despite not having achieved proficiency in English until her 30s. In this case, the initial period of therapy was conducted in English at her request; however, as the therapy proceeded and the woman processed personal aspects of sensitive and traumatic nature, her proficiency in Spanish progressively returned. The description of her experiences in English led to a diminished affective tone, while using Spanish led to a stronger emotional behavior and to the recall of disturbing memories and dreams. In Schrauf (2000), childhood memories appeared to have higher emotional significance when recalled in the L1, and Javier & Marcos (1989) found a correlation between the emotional charge of experiences and the language first associated with the occurrence of those experiences. As research progressed, it identified potential factors of influence that modulate the way in which bilinguals experience emotionality while using different languages (e.g., L1 vs. L2).

2.2.2 Emotional modulation in L2 vs. L1

Four factors seem to be especially related to how bilinguals experience emotions: proficiency, age of acquisition (AoA), learning context, and culture.

Proficiency

Costa et al. (2014) conducted studies investigating whether subjects' moral judgements concerning a situation would be different when processed in their L1 or in their L2. The results did in fact point at a language effect: overall, subjects were more likely to make utilitarian judgements when the moral dilemma was processed in their L2 than in their L1. The authors hypothesized that the increased psychological distance caused by the use of a foreign language results in reduced emotional resonance, which leads individuals to rely less on intuitive processes—and, in that scenario, make deontological judgements favoring the rights of the individual—and more on rational controlled processes—and, in their study, make utilitarian judgements which favored the greater good. However, this effect appeared to be stronger in the group of subjects with lower proficiency, suggesting that increased proficiency can make the L2 more emotionally grounded.

Age of acquisition

While testing early and late Spanish-English bilinguals on their emotional reactions to taboo words, insults, endearments, and reprimands, Harris (2004) found an AoA effect, measured through skin conductance responses. Early bilinguals showed heightened emotional reactions to taboo words in both their L1 and L2, suggesting that they were processing emotion-laden terms in similar ways. In addition, while late bilinguals showed heightened responses to reprimands only in their L1, early bilinguals showed no significant responses to reprimands in either language (for a potential explanation of this phenomenon, see *Culture* below): this second result mirrored that of monolingual English peers tested in a previous study, and it suggested a correspondence between the emotional processing of English L1 subjects and early English L2 bilinguals. These findings are consistent with Bloom & Beckwith's (1989) theory that early language learning occurs at the same time as the development of emotional regulation systems. However, emotional responses do not seem to differ significantly in the case of highly proficient late bilinguals, suggesting that there might be a tradeoff between AoA and proficiency (Harris et al. 2006).

Learning context

Caldwell-Harris' *emotional context of learning* hypothesis (Harris et al. 2006; Caldwell-Harris 2014) suggests that the (emotional) context in which a given language is learned exerts a great influence on the way in which emotionality is experienced while using that language, and that an individual's L1 tends to have higher emotional resonance because it is linked to consistent usage in emotional contexts such as interactions with family and friends. However, consistent usage of the L2 in emotional contexts seems to increase emotional resonance also in that language even when the language is learned later in life (Harris et al. 2006).

Culture

Different behavioural responses to similar stimuli (i.e., childhood reprimands) also led Harris (2004) to argue for the possibility of culture playing a role in modulating emotional processing in the L1 and L2. English monolinguals and early Spanish-English bilinguals showed no significant responses to reprimands in either language. In contrast, late Spanish-English bilinguals and Turkish-English bilinguals showed heightened responses to reprimands in their L1 (Harris 2003), suggesting that cultural differences between the communities speaking the languages may be a potential factor of influence (Harris 2004). A possible explanation for these results, for instance, might be that reprimands carry less emotional weight in the culture of the US compared to that of other countries, such as Turkey, because of the tendencies in children upbringing: early bilinguals may may have internalized US cultural aspects more than late bilinguals, and have therefore displayed less heightened responses to reprimands in any language.

2.3 Emotions and physiological arousal

According to Myers (1998, in Egger et al. 2019), emotions involve physiological arousal, expressive behaviors and conscious experience. Several theories of emotions have tried to relate emotional experiences to physiological arousal and conscious processing.

William James (1884, 1890) argued that physiological arousal precedes emotional experiences: external stimuli first elicit bodily responses, whose feedback then provokes emotional experiences—that is, e.g., we are afraid *because* we tremble, and not tremble because we feel afraid. In James' view, the emotional experience is nothing but a conscious processing of bodily responses, and each emotion corresponds to a specific response pattern that determines its quality (Moors 2009). Around the same time, but independently from James, physiologist Carl Lange proposed analogous ideas, though with a more specific focus on vascular responses (Cannon 1987). Hence, this theory is known as the *James-Lange Theory.*

Cannon (1927) challenged the James-Lange Theory and proposed an alternative theory elaborated upon also by physiologist Philip Bard. The *Cannon-Bard Theory* claimed that emotional experience and physiological arousal take place simultaneously, with no relationship of causation. Emotions lack correspondence with specific bodily response patterns, as the same responses can be indicative of different emotional states—e.g., increased heart rate can be an indicator of fear, anger or joy. Moreover, physiological responses can be experienced with no emotional arousal (e.g., artificial induction by injection of adrenalin), and lack of physiological arousal (e.g., anomaly in physiological feedback) does not imply absence of emotions (Moors 2009, Egger et al. 2019).

A point of convergence between James-Lange's belief that bodily responses precede the emotional experience and Cannon-Bard's argument that emotions cannot be identified by specific response patterns can be found in the *Schachter-Singer Theory,* also referred to as the *Two-Factor Theory of Emotion* (Schachter & Singer 1962; Schachter 1964). Schachter & Singer (1962) found that an injection of adrenalin led subjects to be either happy or angry based on whether they were put in front of a happy or angry individual (confederate in the experiment). They suggested that first the stimulus provokes a state of psychological arousal, and *then* the feedback from such state is elaborated upon, based on the characteristics of the stimulus. That is, emotional experiences derive from the (conscious) cognitive process of attributing a (presumed) cause to the experienced physiological responses (Moors 2009).

Schachter and Singer's idea of the involvement of a cognitive component has since been taken up by several other *appraisal theories,* which posit that the cognitive component is unconscious or automatic, rather than conscious. In addition, they place the involvement of the cognitive component in between the stimulus and the physiological arousal, and not only after the latter. Hence, contrary to what Schachter and Singer claimed, this cognitive component is responsible for determining which stimuli should lead to elicitation, which emotion should be elicited, and how intense it should be. Furthermore, these theories place the identification of a cause for the emotional experience at the end of the episode: the unconscious appraisal of stimuli occurs before the emotional experience, while the conscious attribution of a cause occurs after it. One of the main frameworks in this strand is the *Cognitive Appraisal Theory,* developed by Richard Lazarus (1982, 1991), often referred to as the *Lazarus Theory of Emotion* (Moors 2009; Egger et al. 2019).

2.4 Emotion recognition

Emotion recognition refers to the process of detecting and identifying human emotions. Experimental designs of emotion recognition generally entail emotion elicitation and collection of feedback, either by means of subjective measures (e.g., self-reports) or of observation of more objective ones (e.g., monitoring of physiological variables).

2.4.1 Elicitation

Evoking human emotions in a subject, normally by means of exposure to specific stimuli, varies mainly (though not only) in the choice of stimuli presented to subjects. Many studies (e.g., Uhrig et al. 2016) rely on auditory and visual input, including external stimuli like emotional pictures, videos or short films. The most common emotional picture database is the *International Affective Pictures System* or IAPS (Lang et al. 2008), standardized on valence, arousal, and dominance. Although these elicitation methods allow for standardization across participants, subjects' responses risk being overly modulated by personal experiences and differences (Lench et al. 2011). Music (e.g., Zhang et al. 2014) also allows the standardization of presentation across participants, but again factors such as the participants' will to engage in the experiment and their personal musical tastes may influence their experience and thus their emotions (Lench et al. 2011).

Other studies focus on internal stimuli, such as imagination (e.g., Miller et al. 2002) and autobiographical recall (e.g., Schrauf 2000), or on more complex settings involving real-life manipulation and simulations of realistic situations experienced by the participants (e.g., Harmon-Jones et al. 2007).

In the research on emotional processing in bilinguals, it is not uncommon to use auditory and visual linguistic stimuli in both the subjects L1 and L2 (e.g., Jankowiak & Korpal 2018). However, especially in the case of visual stimuli, the choice most commonly falls on decontextualized single words. That is, the subjects are tested in an environment far removed from naturalistic environments, and thus the findings risk being unrepresentative. Only a limited number of studies has implemented emotional phrases or short narratives in their experimental design, which makes it impossible to generalize results (Sharif & Mahmood 2023). This underscores the need to further investigate emotional processing in cohesive discourse, to understand whether the knowledge gained so far is representative of reality, or whether longer, more complex processing would imply different results.

2.4.2 Self-report

Self-reporting is one of the first, easiest, and most common methods of human emotion recognition. The growing interest in bilinguals' emotional processing and the idea of language-based differentiated emotionality can be traced back precisely to bilinguals' reporting to perceive different levels of emotionality in different languages. For instance, multilingual subjects' responses in Dewaele (2004) pointed at the general tendency to attribute a stronger emotional charge to swear words and taboo words in the L1 vs. the L2.

However, self-reports are subjective measures and can be manipulated by the subjects, whether consciously or not (Korpal & Jankowiak 2018). It is thus a common practice to compare the feedback gathered from self-reports with that of more objective measures, such as physiological variables. Thoma (2024) compared self-report and physiological (i.e., pupil dilation) feedback from German heritage language speakers of Russian or Turkish, on the one hand, and of German learners of English or French as L2 on the other. During the experiment, participants had to listen to heart-warming stories in their two languages. The findings showed an interesting, reversed pattern: the group of heritage speakers showed similar pupil dilation for both languages investigated, but rated the narrative in German to be less emotional than that in their heritage language; German-

English and German-French late bilinguals, instead, reported the narrative to be similarly emotional in both languages, but showed weaker reaction in their L2 compared to the L1. Hence, while self-reports remain a very valuable tool to gain insights into how bilinguals perceive emotions in different languages by subjects, it is safer to accompany such subjective measures with more objective and less manipulable data.

2.4.3 Psychophysiology

Green defined the *psychophysiological principle:* "every change in the physiological state is accompanied by an appropriate change in the mental-emotional state, conscious or unconscious, and conversely, every change in the mental-emotional state, conscious or unconscious, is accompanied by an appropriate change in the physiological state" (Green, et al. 1970, p. 3). In short, every change in the individual's emotional state comes with conscious or unconscious changes in their physiological variables. Yet, the focus on particular physical and physiological expressions as externalizations of emotional states did not arise recently.

Bell (1824) identified *emotions* as affections of the mind that become visible through signs externalized on the face or the body. In his work, he paid particular attention to facial expressions as signals of individuals' emotional states. Such attention is not foreign also to a significant strand of today's research. "Emotion can also be expressed nonverbally. Nonverbal communication […] often accompanies spoken language in the form of gestures and facial expressions" (Liu et al. 2023, p. 2). Based on this, many researchers have developed technologies which attempt to identify individuals' emotions by recognizing their facial expressions. For instance, *Facial Emotion Recognition* (FER) is a system that uses machine learning to spot emotions in visual material (Mellouk & Handouzi 2020).

Nevertheless, facial expressions are not always the most reliable source to recognize emotions (Egger et al. 2019). They easily vary from individual to individual depending on culture, age, gender, manners, personality, ways of experiencing and expressing emotionality, and so forth. Thus, solely relying on facial expressions could lead to misleading or unfair results, affected by many variables out of the researchers' control.

This placed the focus on more reliable variables, derived from physiological processes that occur mostly without the individual's conscious awareness and cannot be so majorly manipulated and modulated by the subject—in particular, on the responses of the *autonomic nervous system* (ANS), responsible for regulating involuntary physiological functions such as respiration, heart rate, blood pressure and so forth (Levenson 2014). ANS responses are often investigated for emotionality and emotion recognition through skin conductance and heart rate. The monitoring of *electrodermal activity* (EDA; also known as *galvanic skin response* or *GSR*) and electrocardiography (ECG) are now frequent methods in emotion recognition research.

Electrodermal activity

Electrodermal Activity (EDA), or Galvanic Skin Response (GSR), refers to the changes in the skin's ability to conduct an electric current (i.e., skin conductance), which occur as a response of the ANS to stimuli (Braithwaite et al. 2013; Li et al. 2022). EDA includes two components, *tonic* and *phasic*.

The tonic component refers to the *skin conductance level* (SCL), the overall level of electrical conductance of the skin, characterized by slow, gradual changes in electrodermal activity (see Figure 5). Low levels of skin conductance indicate calmer and more relaxed states, whereas high tonic EDAs point at states affected by factors such as effort or stress. In normal conditions, changes in the SCL are fairly slow and gradual fluctuations.

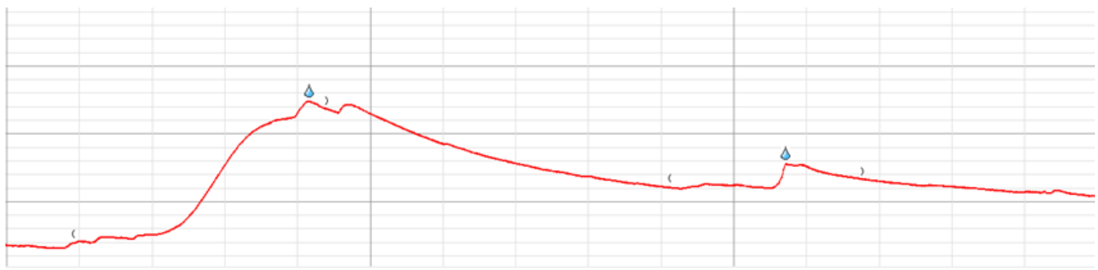

Figure 6. Instance of tonic EDA signal. The peaks of skin conductance responses (SCRs) are marked with a drop. The onset and offset of the SCR are marked with a parenthesis (open or close).

The phasic component, instead, refers to *skin conductance responses* (SCRs), which are faster and more abrupt changes in the skin conductance level (see Figure 6). SCRs come in two ways: *non-specific* SCRs (NS-SCRs), which occur in the absence of identifiable stimuli; and *event-related* SCRs (ER-SCRs), which can be ascribed to specific, eliciting stimuli (Braithwaite et al. 2013; Egger et al. 2019; Li et al. 2022). Given the slow-changing nature of the EDA signal, ER-SCRs are generally considered to have a latency period of 1–3 seconds between the stimulus and the onset of the response. Deflections prior to this timeframe are generally not attributed to the stimulus and are classified as

NS-SCRs. The minimum threshold for SCRs has historically been set at 0.05 µS, but more recent studies (conducted with more precise and refined technologies) are implementing a threshold of 0.04, 0.03 and even 0.01 µS (Braithwaite et al. 2013).

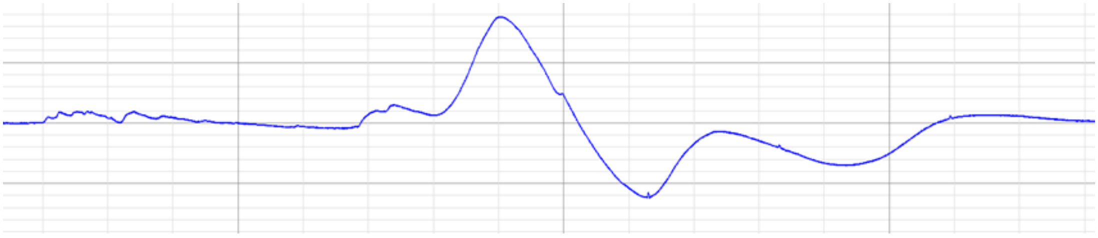

Figure 7. Instance of phasic EDA, characterized by more abrupt changes in the signal.

EDA measurements are taken through electrodes placed on skin areas which are more sensitive to sweat changes thanks to the activity of the eccrine glands, such as palms, fingers and toes (Egger et al. 2019; Dutta et al. 2022), Thus, they are of particular experimental convenience for their non-invasive nature. Different interpretations may be given to *non-invasive* depending on the field of research (e.g., *invasive* may be understood as anything which physically or biologically interferes with a subject). However, it must be clarified that here (and hereinafter) *non-invasive* is understood as not penetrating the subjects' body or altering their biological functions directly, interpretation which is fairly common in the field of Psycholinguistics.

Still, changes in EDA levels may in some cases reflect changes in the engagement of attention or stress and anxiety caused by the task (e.g., Frith & Allen 1983; Caldwell-Harris & Ayçiçeği-Dinn 2020). For this reason, measurements of the EDA signal are often combined with other physiological signals considered indicative of emotional arousal, such as ECG.

Electrocardiography

An electrocardiogram (ECG or EKG) consists of a recording and graphic representation of the heart's electrical activity. One of the main features of such recording is represented by *QRS complexes* (Becker 2006) (see Figure 7). The QRS complex in an ECG represents ventricular depolarization, the process in which ventricular muscle cells rapidly shift from a negative to a positive intracellular charge as sodium ions enter through voltage-gated channels, triggering contraction. It consists of three elements: the Q wave, an initial downward deflection from baseline that reflects depolarization of the interventricular septum; the R wave, a sharp, large upward deflection that represents depolarization of the main mass of the ventricles; and the S wave, a downward deflection following the R wave that reflects the final depolarization of the ventricles (Ashley & Niebauer 2004; Becker 2006).

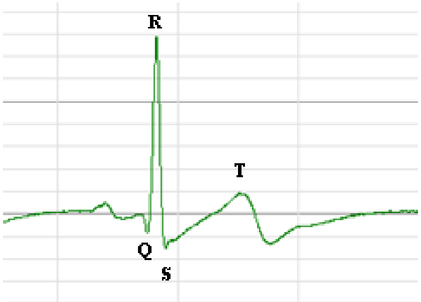

Figure 8. Instance of QRS complex. Q represents the depolarization of the interventricular septum; R represents the depolarization of the ventricles' main mass; S represents the final depolarization of ventricles.

Several features can be derived from the recording of this signal, including heart rate (HR) and heart rate variability. HR is measured in beats per minute (bpm). Though this value's range of variation can be fairly wide depending on the individuals and the situations, a normal heart rate at rest can be considered to be between 60 and 100 bpm (Becker 2006; Tiwari et al. 2021). Heart rate may vary based on the circumstances, and generally increases with physical activity, stress or emotions.

The heartbeat frequency is not constant: for instance, a heart rate of 60 bpm does not necessarily mean that each beat occurs every second. Heart rate variability (HRV) refers to the time variation between heartbeats. Such value is derived from the measurement of the periods of time between two subsequent R waves, or *RR intervals* (see Figure 8). Therefore, in a heart rate of 60 bpm, one RR interval may be of 0.8 seconds, while the following one can be of 1.2 seconds and so forth (Tiwari et al. 2021). HRV is a variable inversely proportional to arousal: decreased HRV implies increased HR (indicative of arousal), while increased HRV implies decreased HR (indicative of a more relaxed state).

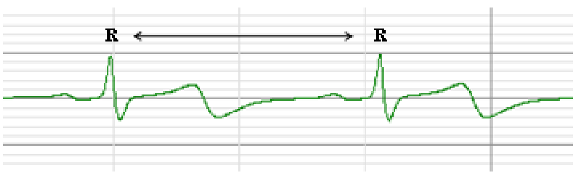

Figure 9. Instance of RR interval—i.e., time occurring between two R peaks.

ECG measurements are also of non-invasive nature. One of the earliest and most renown electrode arrangements for ECG measurements is *Einthoven's triangle.* Developed at the beginning of the 20th century by physiologist William Einthoven, it implies the placement of three electrodes in three different spots of the chest, namely the left upper chest underneath the collarbone, the right upper chest underneath the collarbone and the left side of the torso at the bottom of the ribcage (Becker 2006). Over time, however, researchers have come up with different additional arrangements which involve the placement of the electrodes on other parts of the body (e.g., wrists and ankles).

Physiology in bilingual emotional processing

Most studies focused on differences in emotional processing in bilinguals employ EDA as a physiological parameter. Harris (2004) monitored skin conductance in early and late Spanish-English bilinguals to see if there were any differences between the processing of emotional language (i.e., taboo words, reprimands, endearments and insults) in the subjects' L1 vs. L2. The main difference was found in the processing of reprimands: while early bilinguals showed similar (and not significantly high) responses to reprimands in both their L1 and L2, late bilinguals showed higher reactivity to the reprimands in Spanish (L1) than to those in English (L2). However, both early and late bilinguals showed more heightened responses in the case of taboo words presented in English (L2). Harris (2004) argued that cultural factors may have played a role in the results (see §2.3.2). Harris and colleagues also conducted several other studies which yielded interesting results (e.g., Harris et al. 2003; Caldwell-Harris & Ayçiçeği-Dinn 2009; Caldwell-Harris & Ayçiçeği-Dinn 2020).

Harris (2004) also observed that early bilinguals showed higher skin conductance responses' elicitation with auditory stimuli rather than with visual ones, both in their L1 and L2, while late bilinguals showed no auditory advantage in either language. Jankowiak & Korpal's (2018) study based on EDA monitoring produced different results, as they identified a preference for the visual modality while processing the L1 but not the L2, suggesting psychological distance in the processing of a second language. They argued that such difference in results may be attributed to the fact that Harris (2004) used short expressions and single words whereas they employed longer narratives.

Over time, measuring EDA for emotion recognition has expanded. Rastovic et al. (2019) investigated French-English bilinguals' reactions to swear words, recording heightened reactivity in their L1 than in their L2. In Eilola & Havelka (2011) native and non-native English speakers' SCLs were compared during emotional and taboo Stroop tasks: electrodermal responses to negative and taboo words in native English speakers appeared to be quite significantly higher than those to positive and neutral words, but no significant differences were recorded in the case of non-native English speakers. Naranowicz et al. (2022) studied the influence of L1 and L2 in positive and negative moods, elicited in Polish-English bilingual subjects through the display of affectively evocative animated film clips. The results showed more skin conductance responses in the negative mood in the L1 (compared to the positive), but no significant effect of mood on electrodermal responses in L2.

Interestingly, Naranowicz et al. (2022) reported skin conductance amplitudes being generally higher in the L2 compared to the L1: these findings are consistent with other studies' claim that cognitive load or stress experienced during the completion of a task can lead to an increase in EDA signals. For instance, Caldwell-Harris & Ayçiçeği-Dinn (2020) studied Turkish-English bilinguals dealing with selfish and ethical statements in both their L1 and L2. The participants showed overall higher SCRs in English (L2) than Turkish (L1), and the authors suggested the possibility that the cognitive effort or stress involved in managing a task in a foreign language influenced arousal. Similar results and claims are found in Caldwell-Harris & Ayçiçeği-Dinn (2009), where the authors studied SCRs in Turkish-English bilinguals reading out loud true and false statements.

Several studies (e.g., Rantanen et al. 2013; Seeley et al. 2017; Mather & Thayer 2018) have also correlated emotional processing and regulation with ECG features like HR and HRV, some of which also concerned language. For instance, Buchanan et al. (2006) found a higher likelihood of remembering unpleasant/neutral/unrelated words with HR deceleration, and a higher likelihood to remember taboo words with HR acceleration. Divjak et al. (2024), on the contrary, observed a reduction in participants' HRV with grammatical errors in English speech (increasing number of errors led to decreasing HRV), with a slightly more pronounced reduction when the speaker had a native accent compared to a non-native one.

Rojo et al. (2014) investigated the emotional impact of metaphorical *vs.* non-metaphorical Spanish translations of English figurative expressions by measuring the heart rate of Spanish native speakers presented with short stories containing such translations. The English expressions they used concerned four basic emotions, namely sadness, anger, fear, and happiness: the results revealed an increase in heart rate when processing metaphorical translations compared to non-metaphorical ones for anger, fear, and happiness; interestingly, but consistently with the low-arousal nature of this emotion, an inverse effect was found for sadness, case in which metaphorical translations correlated to a decrease in heart rate. However, literature employing this kind of measurements to investigate emotional processing in bilingual subjects appears to be very limited.

Combining skin conductance and cardiac activity measurements in experimental settings is not new in the emotion recognition literature (e.g., Milstein & Gordon 2020; Raheel et al. 2020; Wang et al. 2022; Yu et al. 2024); however, as in the case of ECG measurements, such combination is hardly ever employed to study emotional processing in bilingual subjects. Lazar et al. (2014) combined EDA and ECG measurements to investigate Hebrew-English bilinguals' emotional processing while carrying out decision-making tasks in both their L1 and L2. The authors expected a reduction in emotional reactivity while the task was carried out in the L2: however, the participants' levels of physiological arousal were higher in English (L2) than in Hebrew (L1). The authors suggested that having to complete a task in a foreign language may have put the participants in a state of anxiety which affected their levels of physiological arousal. A similar dynamic can be found in Gao et al. (2023), where the combination of ERPs and physiological measurements (EDA, ECG, PPG) in Chinese-English bilinguals dealing with morality yielded greater ECG activity in the processing of immoral judgements in the L2 and no significant difference in EDA. Once again, the results were explained with a higher level of anxiety during L2 processing. As mentioned, however, research investigating bilinguals' emotional processing combining EDA and ECG measurements is very limited, and it is therefore hard to generalize any kind of results.

Chapter III
A methodological pilot study on late bilinguals

Chapter II summarized common standards and techniques in emotion recognition research—especially regarding the emotional processing in bilinguals—such as collecting EDA measurements to understand the physiological processing of emotional material and using self-reports to investigate the participants perception and awareness of their emotional states. It also revealed still unexplored areas and gaps to be filled with regards to bilinguals' emotional processing, such as the scarce use of longer narratives as stimuli and the infrequent application of the combination of EDA and ECG measurements to study emotional processing. A deeper understanding of bilinguals' emotionality when different languages are at issue could be extremely beneficial to Cognitive Translation & Interpreting Studies: how do bilinguals (i.e., untrained translators) process emotions when engaged in translation tasks? Does this processing change depending on the language involved (L1 *vs.* L2)? Is emotionality affected more by the source language of the texts or by the target language of the translation? Are bilinguals aware of their own levels of emotionality as they translate?

This is what the study aimed at investigating. As a first step, in the following pages I lay out a proposal to study bilinguals' emotional processing when translating. This proposal was tested in a pilot study on Dutch-English late bilinguals, described below. Given the piloting nature of the study and the limited sample size, no statistical claim is hereby made, and the results of the study cannot be generalized. Rather, the focus of the study is on methodology, and its aim is to test whether the proposed methods can yield interesting observations, with the potential to make a contribution to the field.

3.1 Stimuli

For the purpose of this pilot study, eight texts were selected in order to obtain two sets: four texts in Dutch (NL) and four texts in English (EN). They were all extracts from newspaper articles, written by native speakers of the respective languages involved and published in online newspapers of countries where that language is official (*VRT NWS* and *GVA* for Dutch; *Daily Mail*, *BBC* and *Financial Times* for English). Each set was consisted in two subsets: two "neutral" texts (texts dealing with neutral content) and two "emotional" texts (texts dealing with sensitive, emotional content). Each text was assigned an identifier based on its language (NL; EN), the kind of emotionality (N, neutral; E, emotional) and its position within the subset (1; 2); see Table 1.

		Language	
		Dutch	**English**
Emotional status	**Neutral**	NL_N_1	EN_N_1
		NL_N_2	EN_N_2
	Emotional	NL_E_1	EN_E_1
		NL_E_2	EN_E_2

Table 1. Combined descriptors of stimuli in the study.

Texts may hereafter be referred to by using their respective identifier. In order to verify the kind of emotionality these texts encoded and their ability/inability to arouse emotions, a pre-testing phase was run upon selection and before they were included in the main experiment. The full text of the stimuli is included in Appendix 2.

3.2 Pre-testing phase

The participants in the pre-testing phase were 18 years old or older. The Dutch group consisted in 20 individuals with an average age of 28,11 years; 7 females and 13 males; 3 students and 17 non-students. The English group consisted in 22 individuals with an average age of 30 years; 14 females, 8 males, and 1 non-binary; 7 students and 16 non-students.

3.2.1 Design

Each group was presented with four texts in their L1: two supposedly quite neutral and two supposedly quite emotional. The participants were asked in a Qualtrics survey to read them and to assess both how emotionally charged they considered the texts to be and how strongly they felt Ekman's six basic emotions while reading it.

They assessed the level of emotionality of the texts by stating how emotionally charged they found each one on a 5-point Likert scale: *Neutral, Slightly charged,* *Moderately charged, Very charged* and *Extremely charged* in English; *Neutraal, Licht geladen, Matig geladen, Zeer geladen* and *Extreem geladen* in Dutch.

They assessed how strongly they felt with regards to Ekman's six basic emotions *(anger/boosheid, fear/angst, sadness/verdriet, disgust/walging, happiness/vreugde, surprise/verrassing)* on a 5-point Likert scale: *Not at all, A little, A moderate amount, A lot* and *Extremely* for English; *Helemaal niet, Weinig, Matig, Sterk* and *Heel sterk* for Dutch.

3.2.2 Results

The results of the L1 speakers' assessments met the expectations about the levels of emotionality. In particular, all neutral texts, both in English and Dutch, were rated by the participants as such.

Neutral texts

The number of answers collected for the question about how emotionally charged the texts were was 82 in total—two (Dutch-speaking) participants left the answer blank. Overall, participants recognized the texts as *Neutral/Neutraal* (61%), with a slight tendency towards *Slightly charged/Licht geladen* (22%) and *Moderately charged/Matig geladen* (14.6%), and a minor presence of *Extremely charged/Extreme geladen* (2,4%) answers (see Figures 10, 11, 12, 13).

A slight discrepancy was observed for text EN_N_2 (see Figure 13). A potential explanation for this unexpected result may reside in the correlation between the content of the text at issue and a political situation that changed over the period of time in which the research took place; to prevent such risk in any future attempt, any material featuring political references should be avoided.

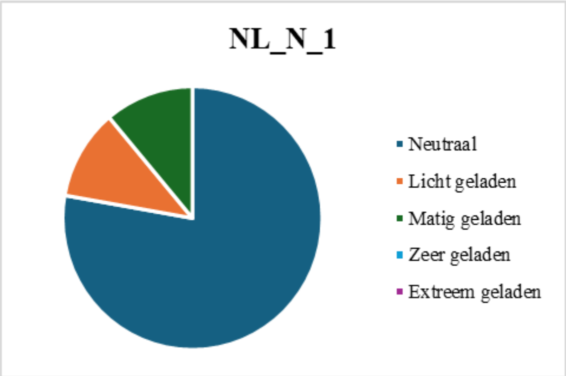

Figure 10. Shares of ratings about the emotional charge of the first neutral text in Dutch.

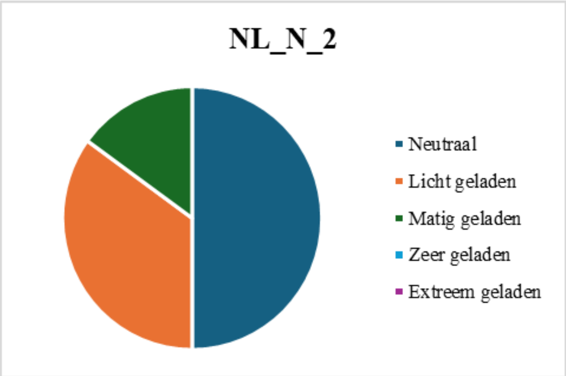

Figure 11. Shares of ratings about the emotional charge of the second neutral text in Dutch.

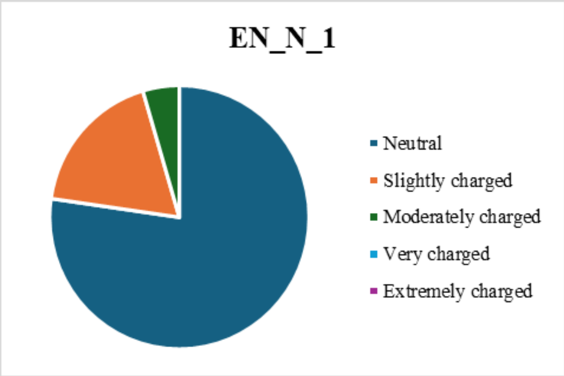

Figure 12. Shares of ratings about the emotional charge of the first neutral text in English.

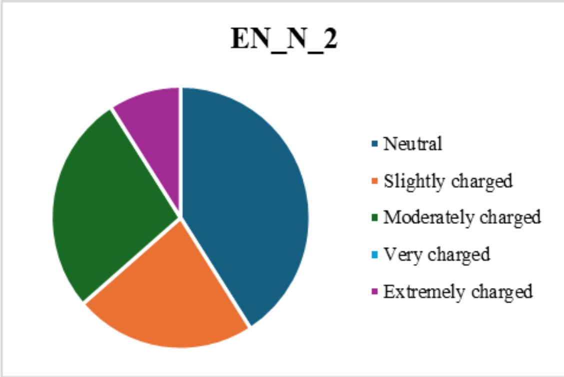

Figure 13. Shares of ratings about the emotional charge of the second neutral text in English.

The same overall tendency towards neutrality was registered also when participants were asked how strongly they felt Ekman's six basic emotions while reading each text. In fact, 73.6% of the 496 answers collected corresponded to *Not at all/Helemaal niet*. Answers which corresponded to *A little/Weinig* (15.3%) and to *A moderate amount/Matig* (7.3%) were mostly relative to emotions such as *happiness/vreugde* and *surprise/verrassing*, and the ratings indicating *A lot/Sterk* (3.0%) and *Extremely/Heel sterk* (0.8%) are very infrequent (see Figures 14, 15, 16, 17 for data on individual texts).

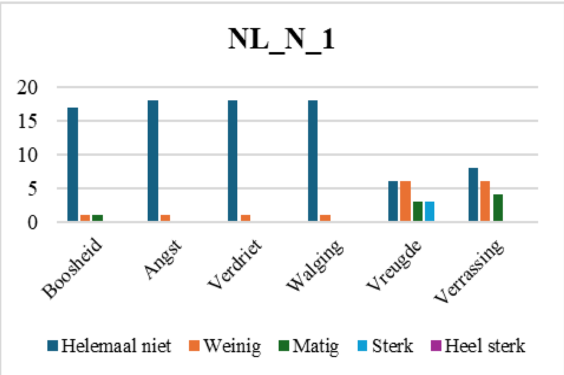

Figure 14. Ratings about the intensity of basic emotions in the first neutral text in Dutch.

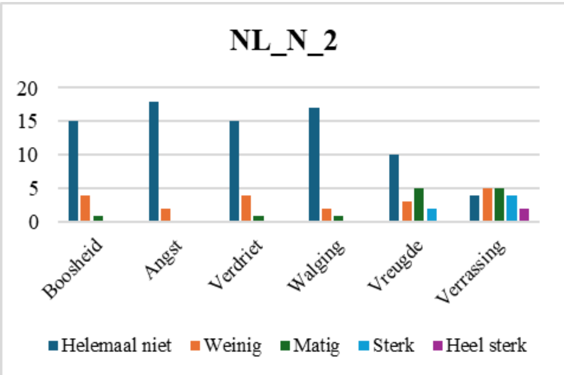

Figure 15. Ratings about the intensity of basic emotions in the second neutral text in Dutch.

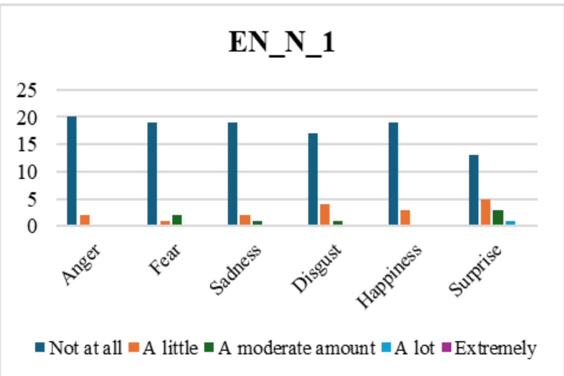

Figure 16. Ratings about the intensity of basic emotions in the first neutral text in English.

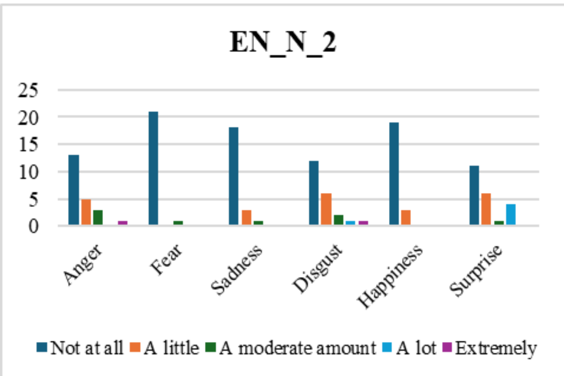

Figure 17. Ratings about the intensity of basic emotions in the second neutral text in English.

The texts in Dutch or English which were expected to be neutral were therefore confirmed to be so by L1 speakers and could be used in the pilot study.

Emotional texts

All participants responded to the question about the emotional charge of these texts, so the total number of answers was 84. They confirmed the expected perception of the texts at issue as emotionally charged, as 69.1% of them indicated the texts as either *Very charged/Zeer geladen* (39.3%) or *Extremely charged/Extreme geladen* (29.8%). A slight tendency towards *Moderately charged/Matig geladen* (15.5%) was also registered, while only a minor number of participants rated the texts as either *Neutral/Neutraal* (8.3%) or *Slightly charged/Licht geladen* (7.1%) (see Figures 18, 19, 20, 21).

The presence of answers assessing the texts as *Neutral/Neutraal* or *Slightly charged/Licht geladen* might be due to the material consisting of newspaper article extracts. For instance, possible explanations may be that the way in which the content is described is fairly neutral, or that people are used to being exposed to sensitive content in this type of texts (i.e., newspaper articles) and thus feel less emotional about it.

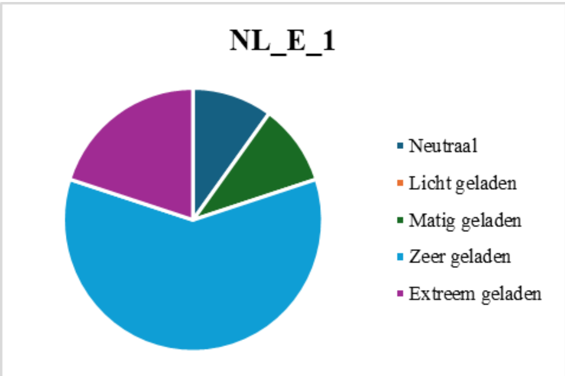

Figure 18. Shares of ratings about the emotional charge of the first emotional text in Dutch.

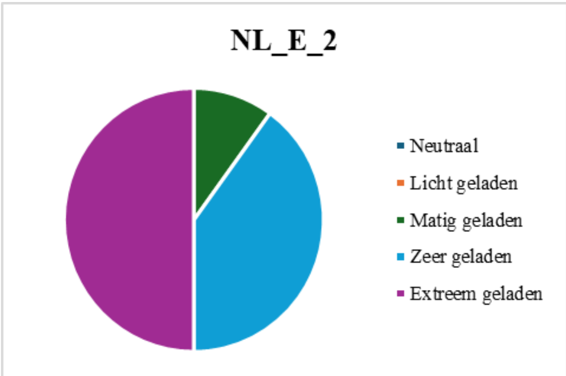

Figure 19. Shares of ratings about the emotional charge of the second emotional text in Dutch.

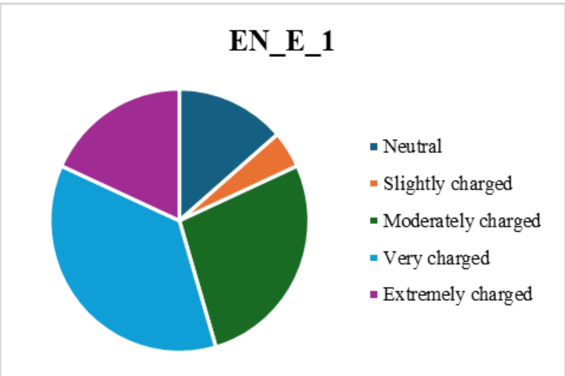

Figure 20. Shares of ratings about the emotional charge of the first emotional text in English.

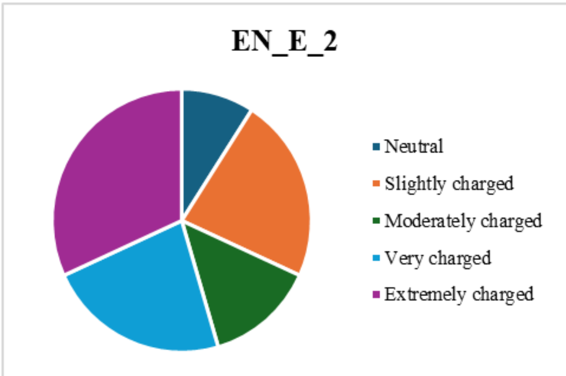

Figure 21. Shares of ratings about the emotional charge of the second emotional text in English.

The assessment of how strongly the participants felt about Ekman's six basic emotions confirmed the stronger emotional component of the texts. Out of the 503 answers collected, 39% corresponded to either *A lot/Sterk* (19.7%) or *Extremely/Heel sterk* (19.3%), with a quite consistent presence of *A moderate amount/Matig* (19.1%) and a minor one of *A little/Weinig* (12.5%) too (see Figures 22, 23, 24, 25). It is true that the highest percentage on its own was registered for the *Not at all/Helemaal niet* answers (148/503 answers; 29.4%), and it may be argued that the texts are then still fairly neutral and do not evoke emotions strongly enough; however, as it can be seen in the graphs below, most of the *Not at all/Helemaal niet* answers referred to either *happiness/vreugde* (53.4%) or *surprise/verrassing* (16.2%), while the other indicators are pretty equally spread across the other emotions. Therefore, such tendency does not represent an indicator of the fact that the texts are not emotionally charged, but shows instead that the emotions evoked are, as expected, mostly negative (i.e., *anger/boosheid*, *sadness/verdriet*, *disgust/walging*).

The tested texts expected to be emotional were confirmed to be so by L1 speakers and could therefore be used in the pilot study.

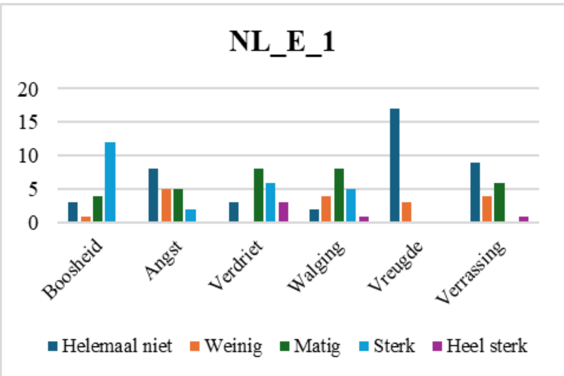

Figure 22. Ratings about the intensity of basic emotions in the first emotional text in Dutch.

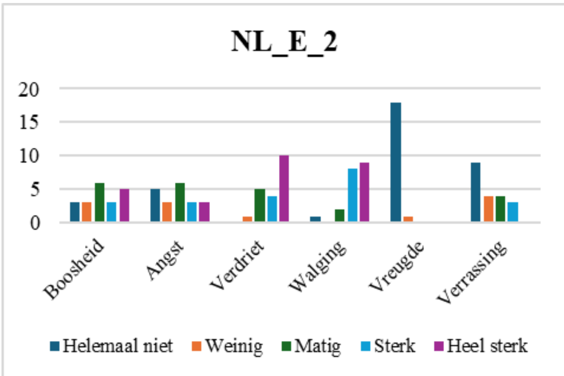

Figure 23. Ratings about the intensity of basic emotions in the second emotional text in Dutch.

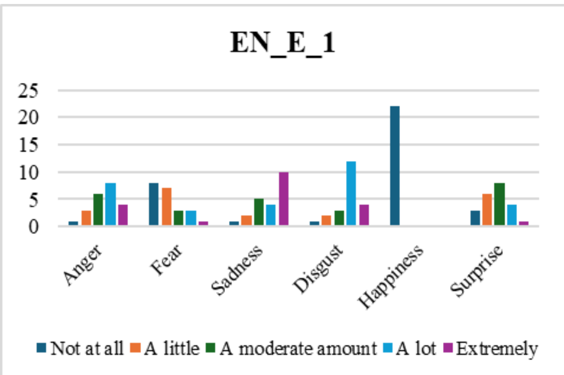

Figure 24. Ratings about the intensity of basic emotions in the first emotional text in English.

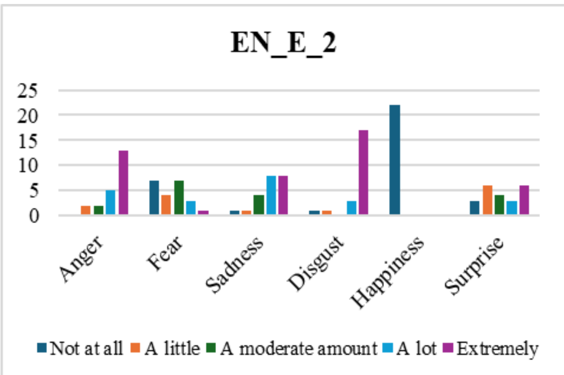

Figure 25. Ratings about the intensity of basic emotions in the second emotional text in English.

3.3 Pilot study

Once the pre-testing phase was completed, the stimuli were integrated into the design of the pilot study, which was conducted at the Department of Experimental Psychology of Universiteit Gent.

3.3.1 Participants

Participants were recruited through a call for volunteers. The sample group of the pilot study consisted of 6 Dutch L1 speakers with an average age of 26.83 years. They were balanced in gender (3 females, 3 males) and all were right-handed and a highly proficient in English as L2. All participants can be considered late bilinguals, as they all started learning English after the cutoff age of 7 (with an average AoA of 10.2). The participants were informed that they could withdraw from the experiment with no consequences and expressed verbal consent to participate in the experiment, as they were peer volunteers and therefore, according to the regulations of the institution in which the study took place, did not need to sign an informed consent.

3.3.2 Physiological measurements

Physiological measurements were taken with the Biopac MP150 System hardware, which allows for the collection of several physiological signals (among which EDA and ECG) through electrodes, leads, and amplifiers. To record, view, transform and analyze the physiological signals and collected data the Acq*Knowledge* 4.3 software was used. The setup of the study involved the use of two computers: the first one was used to record the physiological signals, and is referred to as *Computer 1*; the second one was used to present the participants with the experiment, and is referred to as *Computer 2*. The signal recordings were run on Computer 1, which had both a connection with the Biopac MP150 System and a license for the Acq*Knowledge* 4.3 software.

EDA measurements

For the EDA measurements, a GSR100C amplifier was connected to the Biopac MP150 System hardware. The participants' skin conductance was captured with a TSD203 transducer (attached to the GSR100C amplifier) consisting of two Ag-AgCl, non-polarizable electrodes. The cavities of the transducer containing the electrodes were filled with GEL101 isotonic gel and the electrodes were attached to the participants using Velcro straps. An interval of five minutes was allowed between placing the electrodes and beginning data collection, to enable the gel to warm up and allow optimal signal transmission. This also allowed the participants EDA to return to baseline.

ECG measurements

For the ECG measurements, an ECG2-R amplifier and a BioNomadix wireless transmitter were used. Before applying the electrodes, a slightly abrasive Nuprep Skin Preparation Gel was applied to three areas of the participants chest (Einthoven's triangle) in order to prepare the skin for the electrodes. Then, a small amount of SignaGel was applied to three Kendall Foam Electrodes, which were then placed onto the areas of the participants chest previously treated with the abrasive gel. The BioNomadix transmitter was attached to the participants torso thanks to a band with Velcro straps and the electrodes were connected to the transmitter through a 3-lead electrode clip (BN-EL30-LEAD3). This procedure was carried out while waiting, after placing the electrodes for the EDA measurements and before beginning the data-collection, and was completed before the end of the waiting time.

3.3.3 Procedure

The script for the pilot study was written with PsychoPy, an open-source Python- based software, and was run on Computer 2—different from the one on which the physiological signals were recorded—through which the participants were presented with the stimuli and the study.

Each participant was presented with only one of the two subsets of texts, so that three participants were tested with one series of texts and the other three with the other one. The order in which the participants were presented with the texts was randomized. Participants were tested individually. For each participant, data collection started after all preparatory steps required by the study setup had been completed (e.g., the placement of electrodes for the detection of physiological parameters). The study and its instructions, with the exception of the L1 stimuli (in Dutch), were presented to the participants in English.

At the beginning of the experiment, the participants carried out an initial self-evaluation in order to report their underlying emotional state. In this self-evaluation, the participants were asked how strongly they felt with regards to Ekman's six basic emotions (namely *anger, fear, sadness, disgust, happiness* and *surprise*) on a 7-point Likert scale *(Not at all, Very slightly, Slightly, Moderately, Quite a lot, Very much, Extremely).*

After the initial self-evaluation, the participants started the main part of the study, which consisted of four tasks, each with a different condition (neutral content in L1; neutral content in L2; emotional content in L1; emotional content in L2). At the beginning of every task, the participants watched a video featuring footage of natural scenery and slow, relaxing music, with the intent of bringing them (back) to a baseline state of relaxation. Each video lasted 60 seconds and participants had to watch it entirely.

Once the video was over, participants were automatically redirected to a reading task: the participants were shown a text in one of the four conditions and had to read it through. Once they read it entirely, they had to click on a button labeled *Ready to translate.* This made it possible to determine the time span which the participants devoted to (only) reading the text for the first time, so that the emotional impact of reading in each of the four conditions could be analyzed.

After clicking on the *Ready to translate* button, participants had to translate the text they had just read into the other language of the combination (e.g., Dutch→English). Translations were carried out by hand on pages provided by the experimenter. If needed, participants could refer to two open-source online dictionaries available on Computer 2. Once done with translating, the participants had to click a button labeled *Done translating,* which directed them to a self-evaluation concerning their emotional states while translating and featuring the six basic emotions and the 7-point Likert scale also included in the initial self-evaluation. After having filled in the information about their emotional states during translation, the participants were automatically redirected to the following task, which had the same structure but involved a different condition.

In order to proceed through the tasks of the experiment and fill in the requested information (e.g., self-evaluations about their emotional states) the participants interacted with Computer 2. The script allowed for the retrieval of information concerning the session (e.g., the type of stimuli and the order in which they were presented) and the participants retrospective data (e.g., self-evaluations answers).

The participants translated the stimuli texts by hand, as typing on the translation on the computer would have led to a significant amount of noise in the EDA measurements. The researcher supervised all data-collection sessions entirely, and the participants were informed that they could request a break at any time. Only one participant asked for a short break halfway through the session, and the recording of physiological parameters and presentation of the stimuli were suspended during that break.

At the end of the experiment, the recording of physiological signals was interrupted and all the equipment attached to the participants was removed.

3.3.4 A potential outlier

A few remarks need to be made about one of the participants. Most EDA physiological responses of one individual appeared to be internally consistent but fairly divergent from those of the rest of participants. This may be linked to several factors. For instance, during the data-collection session, the participant appeared to be in distress due to the nature of the trial, its duration and its modalities: later feedback from the participant confirmed this hypothesis. Moreover, the participant reported to sometimes struggle with anxiety, to have always generally experienced heightened sweating and to have felt warm during the experimental session because of the choice of clothing. However, only his EDA parameters showed unusual tendencies, whereas ECG values aligned with those of the other participants.

Given the small sample size of this pilot study, there are no grounds to claim with certainty that this participant is an outlier, and therefore his data was retained for the purpose of the current analysis. However, for the sake of transparency, Appendix 3 provides tables with the EDA data excluding this participant.

3.3.5 Results

The results concern two different kinds of data: retrospective (coming from the self-evaluations carried out by the participants at the beginning of the experiment and after its individual components) and physiological (coming from the real-time measurement of participants physiological variables during the experiment).

Retrospective data

Overall, the participants carried out five self-evaluations in the course of the study. The first one was conducted at the very beginning of the experiment, and it was aimed at understanding the participants' underlying emotional state. As expected, the results from this initial evaluation of the participants emotional states returned pretty neutral results, with all emotions being mostly rated as not felt at all (see Figure 26).

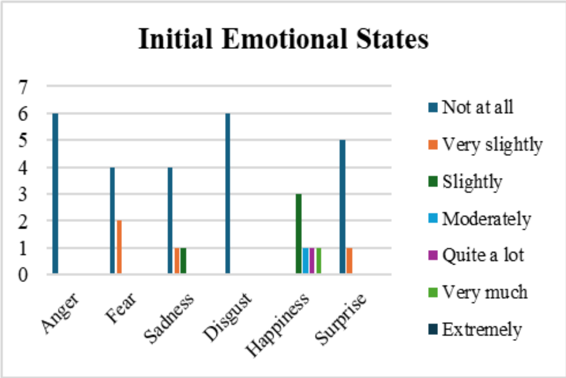

Figure 26. Results from participants' self-evaluations of their emotional states at the beginning of the experiment.

During the experiment, the participants were asked to conduct similar self-assessments at the end of each translation sub-task, with regard to the emotions they felt while translating. Overall, participants reported feeling more emotional during the translation of emotional texts, compared to neutral ones. When looking more closely at neutral texts, participants reported higher emotional charge when translating the text from English (L2) into Dutch (L1) than the opposite (see Figures 27, 28).

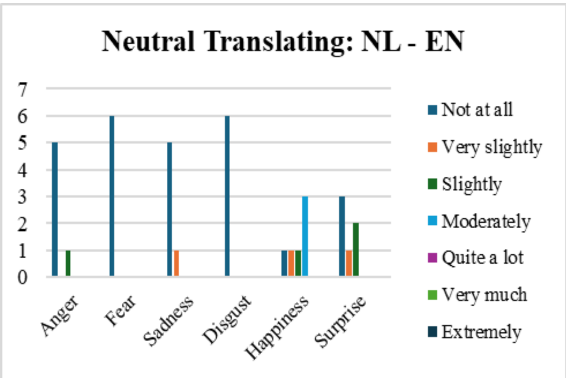

Figure 27. Results from participants' self-evaluations of their emotional states during the translation of neutral content from Dutch into English.

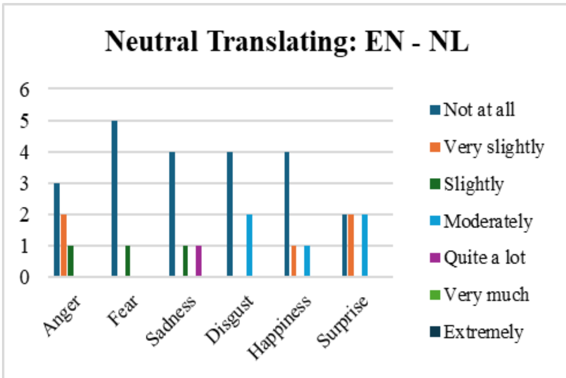

Figure 28. Results from participants' self-evaluations of their emotional states during the translation of neutral content from English into Dutch.

As for the emotional texts, two main remarks can be made. If any rating which differs from *Not at all* is considered, the translation of emotional content from Dutch (L1) into English (L2) seems to be the one felt as more emotionally charged. However, if only stronger emotional ratings (i.e., *Moderately*, *Quite a lot*, *Very much*, *Extremely*) are taken into consideration, not only the two language conditions show almost equal ratings, but the translation from English into Dutch received a minimally higher rating than the one from Dutch into English (10 ratings for the former *vs.* 9 ratings for the latter) (see Figures 29, 30).

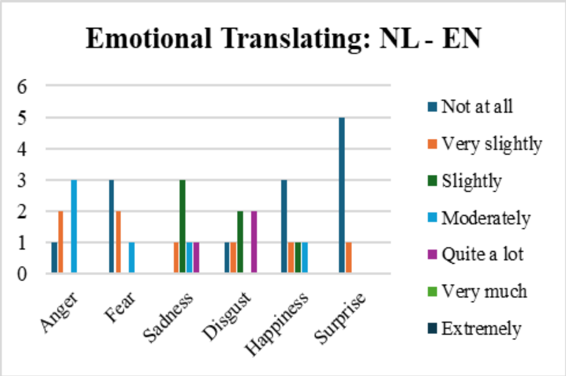

Figure 29. Results from participants' self-evaluations of their emotional states during the translation of emotional content from Dutch into English.

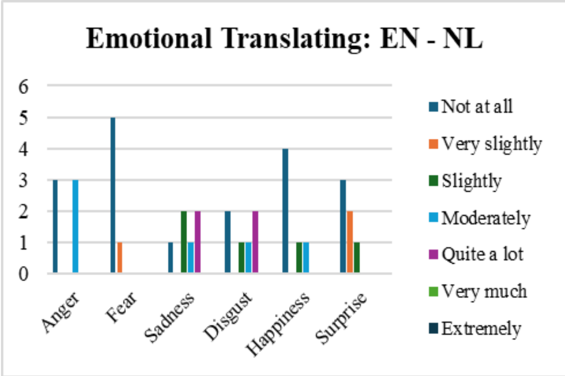

Figure 30. Results from participants' self-evaluations of their emotional states during the translation of emotional content from English into Dutch.

Physiological data

For this analysis, the reading and the translation tasks are considered separately. Therefore, eight conditions are hereby addressed: reading neutral content in Dutch (R_N_NL); reading neutral content in English (R_N_EN); reading emotional content in Dutch (R_E_NL); reading emotional content in English (R_E_EN); translating neutral content Dutch→English (T_N_NL-EN); translating neutral content English→Dutch (T_N_EN-NL); translating emotional content Dutch→English (T_E_NL-EN); and translating emotional content English→Dutch (T_E_EN-NL).

Tables 2 and 3 display the averages of the participants' data, with standard deviations indicated in parentheses. In Table 2, for instance, the average mean tonic EDA (expressed in microsiemens) for the task which involved reading a neutral text in Dutch is 8.576 with a standard deviation of 3.69. Box plots are also provided to better illustrate the distribution of the data (see Figures 31-44). For the sake of space, only some of the features extracted from the physiological data (the ones believed to be best suited to understand the levels of emotional arousal based on the design of this study) are hereby reported; a more extensive list of features is included in Appendix 4.

Reading tasks

	R_N_NL	R_N_EN	R_E_NL	R_E_EN
Mean Tonic EDA (µS)	8.58(3.69)	8.9(3.66)	8.78(2.97)	8.89(4.26)
Highest Tonic (µS)	10.11(4.71)	10.8(5.72)	10.96(4.78)	10.71(5.08)
Highest Phasic (µS)	0.58(0.52)	0.99(1.23)	1.32(1.26)	1.09(0.9)

SCR count	3(2.28)	4.5(5.75)	2.83(1.33)	3.67(1.37)
SCR/min	2.46(1.8)	2.03(1.3)	2.26(1.02)	2.57(0.75)
HR (bpm)	69.31(10.75)	67.13(11.73)	67.03(12.32)	65.97(10.52)
HRV (s)	0.9 (0.15)	0.93(0.17)	0.89(0.11)	0.94(0.16)

Table 2. Averages of the physiological variables in reading tasks. SDs in parentheses.

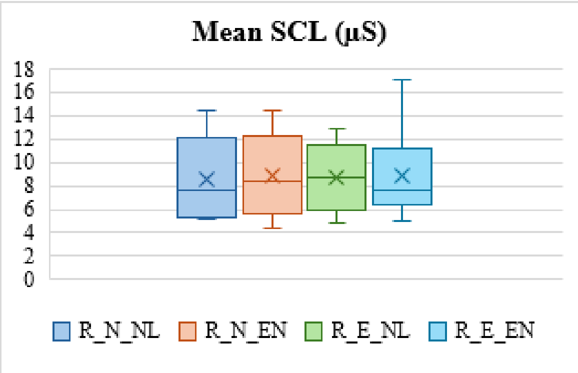

Figure 31. Distribution of mean SCL (µS) data in the four reading conditions.

Figure 32. Distribution of highest SCL (µS) data in the four reading conditions.

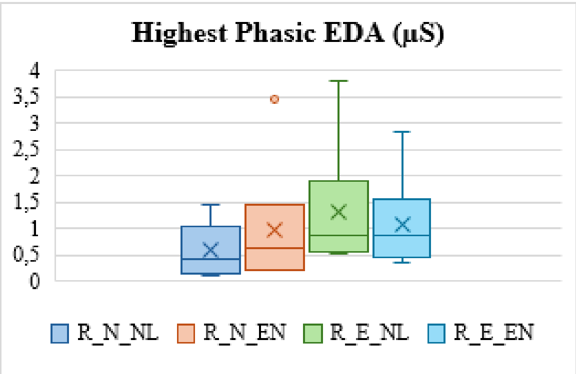

Figure 33. Distribution of highest phasic EDA (µS) data in the four reading conditions.

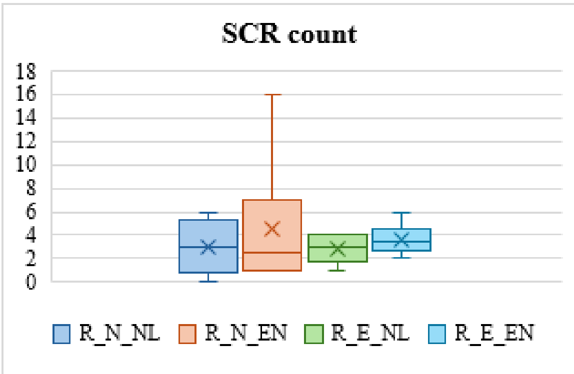

Figure 34. Distribution of mean SCR count data in the four reading conditions.

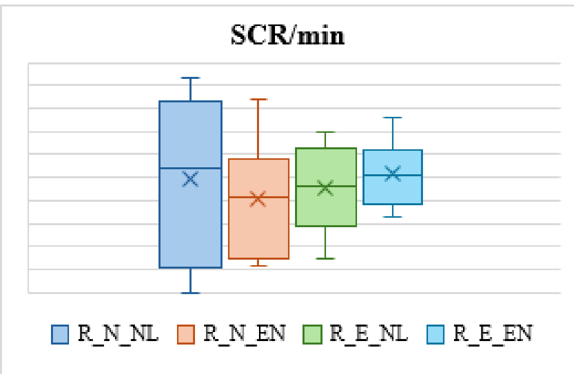

Figure 35. Distribution of SCR/min data in the four reading conditions.

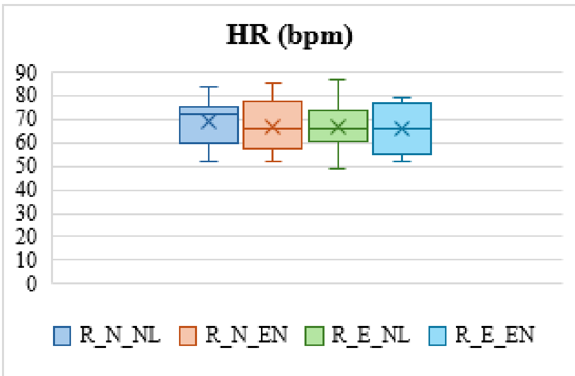

Figure 36. Distribution of HR (bpm) data in the four reading conditions.

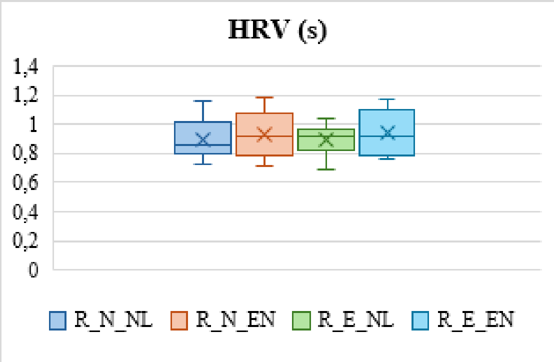

Figure 37. Distribution of HRV (s) data in the four reading conditions.

Translation tasks

	T_N_NL-EN	T_N_EN-NL	T_E_NL-EN	T_E_EN-NL
Mean Tonic EDA (µS)	8.52(3.82)	8.55(3.44)	8.9(3.1)	8.12(3.71)
Highest Tonic (µS)	11.51(5.37)	11.7(5)	12.44(5.32)	11.21(4.66)
Highest Phasic (µS)	1.28(1.06)	1.3(0.81)	1.38(1.02)	1.01(0.748)
SCR count	42(31.41)	43.67(21.57)	53.33(35.8)	46.17(49.59)
SCR/min	2.47(1.28)	2.46(1.13)	2.94(1.3)	2.47(2.07)
HR (bpm)	71.95(10.9)	72.05(12.73)	72.27(13.85)	69.91(9.83)
HRV (s)	0.86(0.13)	0.86(0.15)	0.86(0.16)	0.88(0.13)

Table 3. Averages of the physiological variables while translating. SDs in parentheses.

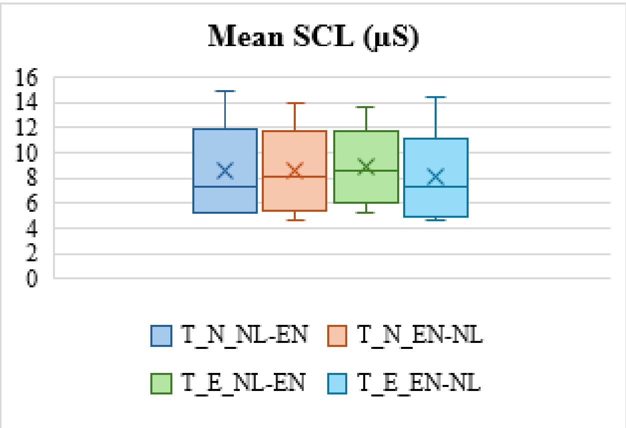

Figure 38.. Distribution of mean SCL (µS) data in the four translation conditions.

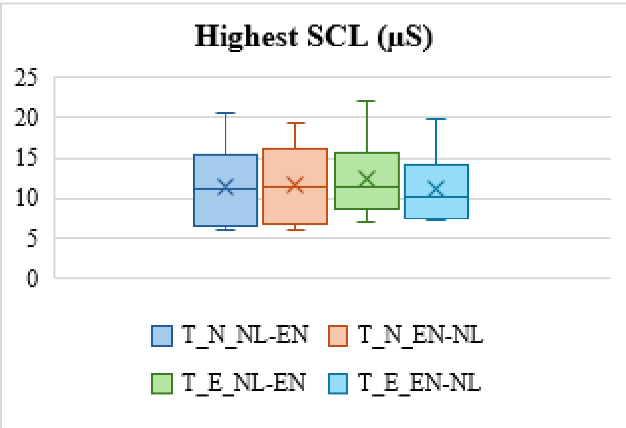

Figure 39. Distribution of highest SCL (µS) data in the four translation conditions.

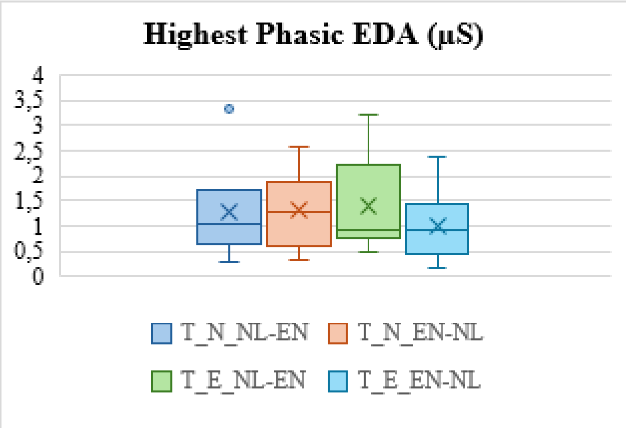

Figure 40. Distribution of highest phasic EDA (µS) data in the four translation conditions.

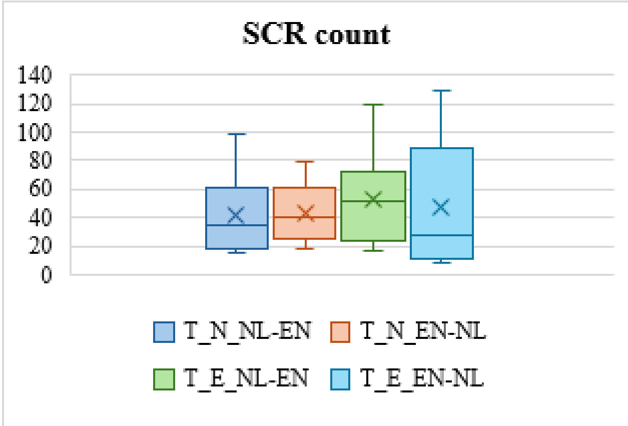

Figure 41. Distribution of SCR count data in the four translation conditions.

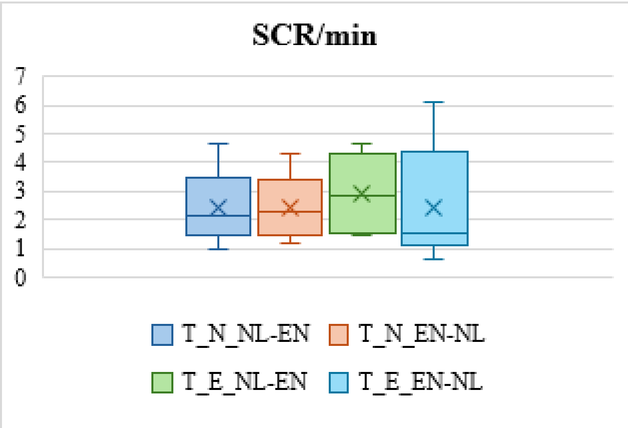

Figure 42. Distribution of SCR/min data in the four translation conditions.

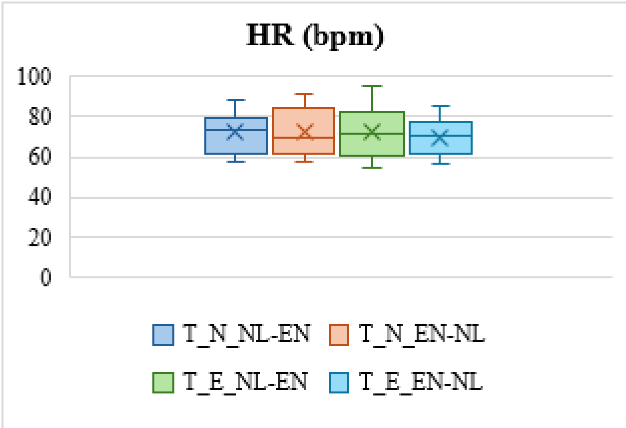

Figure 43. Distribution of HR (bpm) data in the four translation conditions.

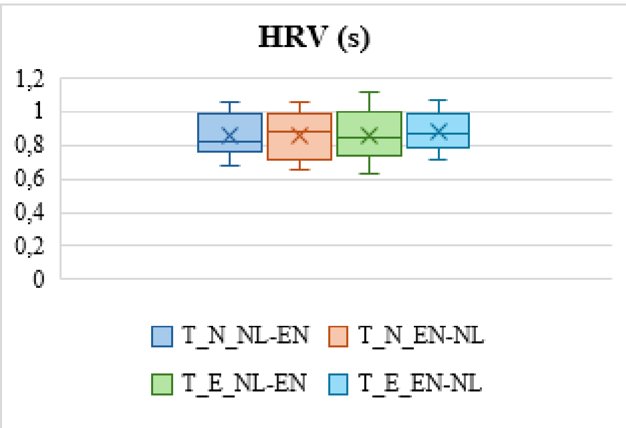

Figure 44. Distribution of mean HRV (s) data in the four translation conditions.

3.3.6 Discussion

The physiological data is analyzed by focusing on two comparisons: (1) between results from texts with the same level of emotionality, but different source languages (Dutch neutral *vs*. English neutral; Dutch emotional *vs*. English emotional); and (2) between results from texts with different levels of emotionality, but the same source language (Dutch neutral *vs.* Dutch emotional; English neutral *vs.* English emotional).

Let us first address (1), texts with the same level of emotionality but different source languages. As expected, the participants showed overall higher reactivity when dealing with emotional content presented in their L1—i.e., when reading an emotional text in Dutch—and when translating an emotional text from L1 into L2. The tendency seems less strong when reading than when translating. However, the data may have been influenced by a potential outlier with especially high EDA values (see § 3.3.4).

The neutral texts revealed an opposite tendency: participants' physiological responses were generally higher when they were reading neutral texts in their L2 and when they were translating neutral texts from their L2 into their L1. A potential explanation for this may be found in the conscious or unconscious higher levels of attention, stress and anxiety caused by having to carry out fairly complex tasks in a non-native language, or where the native language dominates the task (for similar results in other studies see §2.4.3). More about this will be said below.

Comparing texts with different levels of emotionality but in the same language (2) yields a similar pattern. With the texts in Dutch, the highest physiological responses were elicited by tasks with emotional content. With texts in English, however, higher physiological responses were registered with neutral contents rather than with emotional ones. Again, a potential explanation might consist in higher levels of stress or anxiety entailed in the completion of tasks in a non-native language. The processing of tasks with emotional content in the L2 would generally be expected to yield high physiological reactivity, and presumably higher than the one elicited by L2 texts featuring neutral content, but it is not the case in this study. This may not have occurred if the emotional detachment caused by the processing of an L2 was significant enough to obscure and dampen any kind of emotional arousal, including that related to stress and anxiety.

An alternative explanation concerns a potential emotional ambiguity of one the neutral English texts included in the experiment: the text EN_N_2 was rated slightly higher on emotionality compared to the another neutral texts both in English and in Dutch (see § 3.2.2). However, it is unlikely that the results were driven by a potentially higher level of emotionality of text EN_N_2 for two main reasons: first, only half of the participants was presented with that text; second, this would not explain the lower results in processing L2 emotional texts, which were both rated as substantially more emotional than the neutral ones.

Two other observations can be made by looking at the results: first, the level of emotionality experienced by the participants seems to be determined by the language *from* which the text is translated, the text's source language. In fact, a correlation can be observed between the texts which elicited higher physiological responses in one task and those which did it in the other: for instance, reading a text featuring emotional content *in Dutch* caused in the participants higher physiological responses, and so did translating a text featuring emotional content translated *from Dutch* into English. If it was the target language the one to influence an individual's emotional states when translating, then we should have observed greater physiological reactivity in the translation task involving translation from English *into Dutch*. In view that the limitations of this work allow only for speculative statements, we can hypothesize that the emotional experience when translating may be determined by the source text language, and not by the target language.

The second phenomenon is that most of the values indicative of emotional arousal (i.e., highest tonic EDA, highest phasic EDA, SCR/min, HR and HRV) were higher (in the case of HRV, lower) when translating than when reading. Translating seems to have a heightened emotional impact. Given the complexity of translating and the cognitive effort required, it would be reasonable to expect milder emotions when at task; however, translation scored higher than reading on intensity of almost all physiological parameters considered, thus suggesting that translating has an emotional impact on the individual at task which is not only high, but higher than reading.

Finally, comparing the results of the self-evaluations with the physiological findings yielded a clear correspondence in neutral texts: the higher physiological responses observed when translating L2→L1 mirror the higher emotional ratings the participants attributed to translating. However, when translating emotional content, the physiological responses indicate a clear emotional predominance in the process of translating Dutch→English but the participants gave approximately the same score of stronger emotional ratings to translating in both directions (see § 3.3.5).

3.3.7 Limitations and further analyses

As mentioned, the present pilot study has a small sample size, no inferential statistical tests were performed, and no generalized claim can be made. However, in the case of a larger group of investigated participants, further analyses with more statistical power would be advisable. Options to consider may be the calculation of z-scores and of the percentage of increase/decrease of each parameter with respect to baseline values for each condition investigated (see Table 4).

	R_N_EN – Mean SCL (μS)				
	Value	Baseline	AVG(SD)	z-score	% of increase
P01	8.73	8.49	8.55(3.44)	0.052	2.81

Table 4. Instance of further analyses which can be conducted on the participants data when the sample size allows for reliable statistical analyses.

In any case, this pilot study was a useful tool to corroborate the feasibility and adequacy of the proposed methods and to identify potential trends to be investigated further on a larger scale in the near future.

Conclusions

The third chapter proposed a methodology to investigate the emotional processing in bilinguals engaged in tasks entailing reading and translating. Such methodology, based on subjective measures (i.e., self-evaluations) and objective measures (i.e., EDA and ECG monitoring), was tested through a pilot study on Dutch-English proficient bilinguals. Higher reactivity was expected in response to emotional texts compared to neutral texts, and to L1 compared to L2. However, the results only partially met the expectations.

As expected, the reading task dealing with emotional content in the L1 yielded higher responses than that dealing with emotional content in the L2. However, when comparing the reading tasks dealing with neutral content, higher responses were elicited by the task in the L2 rather than by the task in the L1. Other studies with similar results have proposed higher levels of stress and anxiety caused by carrying out a task in the L2 as a potential explanation for the phenomenon. The reading of texts dealing with neutral content in the L2 also produced higher physiological responses than the reading of texts dealing with emotional content in the same language. Such result may seem paradoxical: however, this might have occurred because the emotional detachment caused by the processing of content in the L2 was significant enough to obscure and dampen any kind of emotional arousal, including that related to stress and anxiety.

The results of the translation tasks mirrored those of the reading tasks when the language of the reading task was the source language of the translation task: for instance, reading a text featuring emotional content *in the L1* elicited in the participants higher physiological responses, and so did translating a text featuring emotional content translated *from the L1* into the L2. This result suggests that it may be the source language of the text which influences the levels of emotionality of the translation process, and not its target language. Moreover, given the cognitive effort required by the activity of translating, it would be reasonable to expect milder emotions when engaged in this task: however, most physiological responses were higher when translating than when reading, suggesting that translating may have a heightened emotional impact.

When comparing the results of the self-evaluations to those of the physiological monitoring, a clear correspondence was observed for neutral texts, as the higher physiological responses registered in the process of translating from the L2 into the L1 mirrored the higher emotional ratings given by the participants. However, whereas higher physiological responses were observed in the process of translating from the L1 into the

L2, the participants attributed approximately the same ratings to both translating directions.

This study had some limitations that do not allow for generalization. It also had minor flaws that become positive in that they will be mended when carrying out a major study with a larger sample. One of the two English neutral texts which the participants were presented with is of slightly ambiguous emotionality, and, although this should not have had an impact on the data, it asks for a more thorough control in further work. In addition, one of the participants was identified as a potential outlier. Most importantly, the limited sample size of this pilot study allows only for speculative statements, and that no generalization or statistical claim can be made based on this data. However, the study served as an effective tool to validate the feasibility and adequacy of the proposed methods, and yielded results which point at potential trends to be more extensively investigated in the near future.

In fact, a request for funds to support a doctoral program aimed at exploring this subject has been issued by the undersigner. A larger-scale replication of the methodology hereby proposed could provide insights for further research: for instance, it could prompt investigations on the influence of language distance in bilinguals' emotional processing, or comparisons between bilinguals' physiological responses and neural activity (as measured through EEG studies) during the processing of emotional content and translation tasks.

Although academic interest in these phenomena has gathered momentum only in the last decades, bilingualism and emotionality are relevant to several fields, and in particular to those of psycholinguistics and cognitive translation and interpreting studies (CTIS): a further investigation of the subject discussed in this work would only be beneficial for both fields, and it would shed light on the dynamics involved in the emotional experiences of bilingual individuals as well as in the subjects' engagement in the translation process.

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Appendix 1

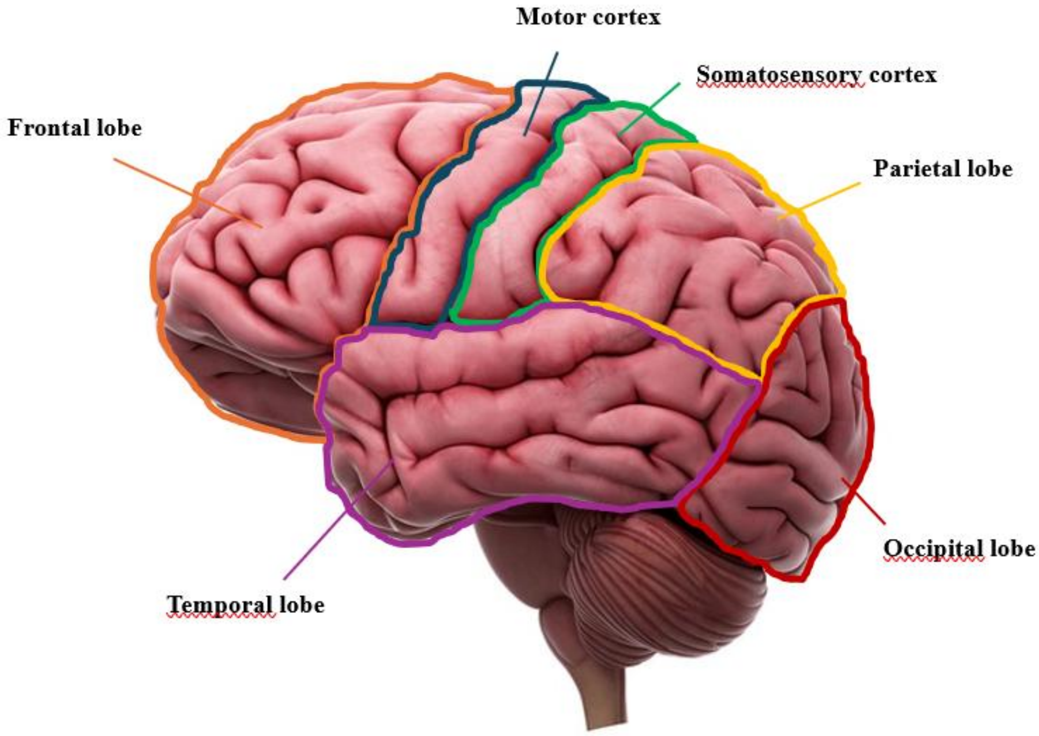

Figure 35. Image adapted from https://www.istockphoto.com/photo/medical-illustrate-gm484757150-71487927, accessed on March 1st, 2025. Credit: SciePro.

Frontal lobes: are involved in processes such as thinking, planning, organizing, problem-solving, short-term memory and movement.

Motor cortex: is involved in planning, controlling and executing voluntary movement.

Occipital lobes: are involved in vision and image processing and help connect such visual information with images stored memory.

Parietal lobes: help interpret sensory information and feelings, identify objects and understand spatial relationships.

Somatosensory cortex: is involved in detecting and processing sensory information received from the body, e.g. regarding temperature, taste, touch and movement.

Temporal lobes: help process information from your senses of smell, taste and sound, and play a role in memory storage, speech and musical rhythm.

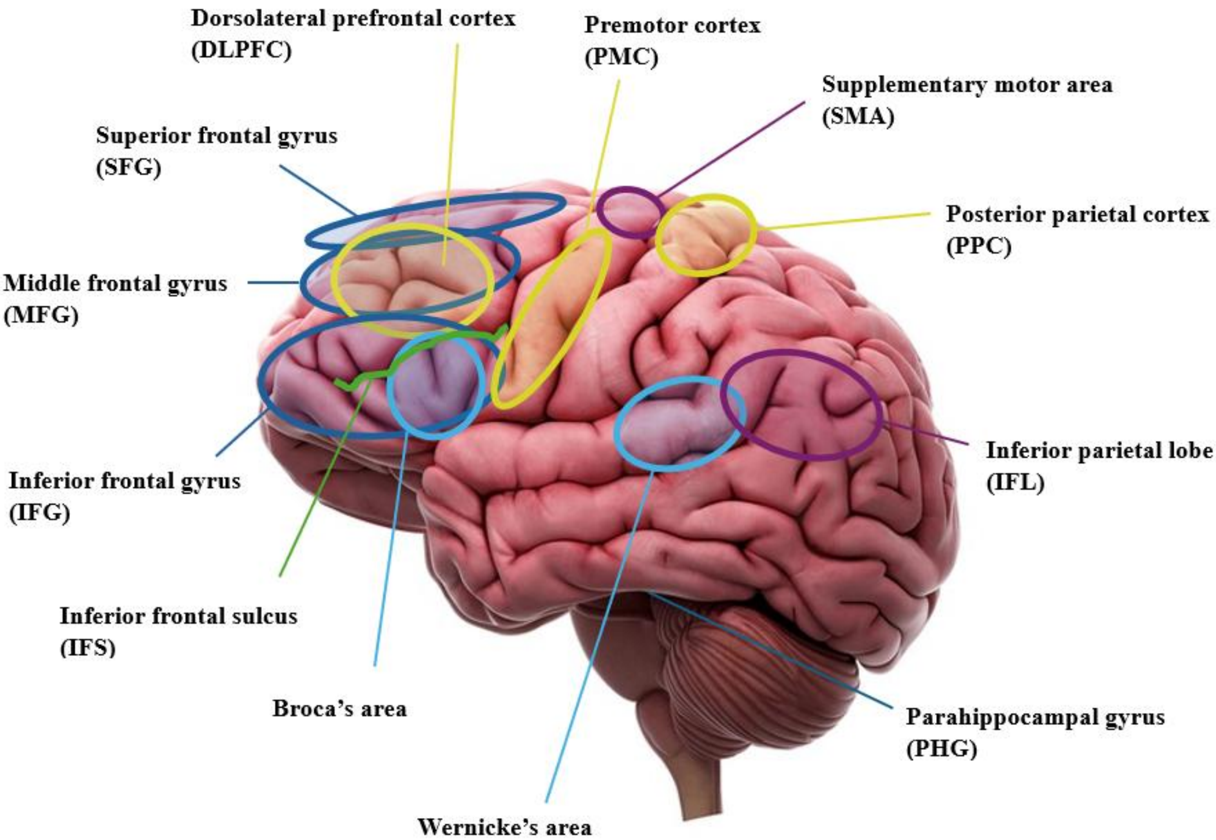

Figure 46. Image adapted from https://www.istockphoto.com/photo/medical-illustrate-gm484757150-71487927, accessed on March 1st, 2025. Credit: SciePro.

Broca's area: responsible for language production.

Dorsolateral prefrontal cortex (DLPFC): responsible for executive functions such as task switching, prevention of interference, inhibition, planning, and working memory.

Inferior frontal sulcus (IFS): responsible for cognitive control and verbal working memory, including semantic processing, serial order processing, and phonological working memory.

Inferior parietal lobe: responsible for neural operations that span from basic attention to language and social cognition (and thought to be involved also in emotion recognition).

Parahippocampal gyrus (PHG): responsible for cognitive processes (such as memory encoding and retrieval) and emotional processing.

Posterior parietal cortex (PPC): responsible for spatial perception, visuomotor control or directing attention.

Premotor cortex (PMC) and supplementary motor area (SMA): responsible for planning and organizing simple and complex movements.

Superior, middle and inferior frontal gyrus (SFG, MFG and IFG): responsible for executive functions, including working memory and inhibitory control.

Wernicke's area: responsible for language comprehension.

Appendix 2

1. NL_N_1

10 topwandelingen in Nationaal Park Hoge Kempen krijgen Europees keurmerk 'Leading Quality Trail'

(https://www.vrt.be/vrtnws/nl/2024/09/03/10-topwandelingen-in-nationaal-park-hoge-kempen-krijgen-europees/)

10 dagwandelingen in het Nationaal Park Hoge Kempen krijgen begin oktober het Europese kwaliteitslabel 'Leading Quality Trail - best of Europe'. Het is de European Ramblers Association die de wandelingen beoordeelt. Die organisatie heeft eerder ook al de National Park Trail, een langeafstandswandeling van 110 kilometer in het Nationaal Park Hoge Kempen, het Europees keurmerk gegeven.

De afgelopen dagen zijn twee inspecteurs en een student van de European Ramblers Association op pad geweest in de tien wandelgebieden van het Nationaal Park Hoge Kempen. Het is dezelfde organisatie die eerder ook al de langeafstandswandeling in het Nationaal Park beoordeeld heeft, en die wandeling het kwaliteitslabel 'Leading Quality Trail - best of Europe' gegeven heeft. Maar de inspecteurs beoordelen ook dagwandelingen. Daarom hebben de mensen van het Nationaal Park Hoge Kempen nu in elk van de 10 wandelgebieden een wandeling geselecteerd, en die zijn de afgelopen dagen beoordeeld.

"We hebben eens bekeken in de 10 wandelgebieden van het Nationaal Park Hoge Kempen welke wandeling we echt zouden willen aanbevelen. Het gaat dan bijvoorbeeld om de wandeling aan de Commanderij van Gruitrode richting de Oudsberg, de wandeling in Thorpark in Genk, de wandeling over de lange terril en dubbele terril in Eisden, de wandeling in de vallei van de Ziepbeek in Lanaken of de wandeling op de Mechelse heide en het Mechels bos in Maasmechelen". Het zijn allemaal dagwandelingen, de meeste variëren tussen 10 en 15 kilometer. De inspecteurs gebruiken strenge criteria waaraan de wandeling moet voldoen. Johan Van Den Bosch somt op: "Verharde paden moeten tot een minimum beperkt zijn. Het moet om een natuurlijke omgeving gaan en het moet er stil zijn. De bewegwijzering moet bovendien perfect

zijn, het moeten wandelingen zijn die iets vertellen over natuur en landschap, en er moet variatie zijn in die landschappen."
"De inspectie was succesvol voor alle 10 wandelingen", zeggen de inspecteurs. Ze hebben het in hun rapport over een variatie aan landschappen, van heide en bossen tot historische mijnsites, panoramische uitzichten vanaf de terrils en serene meren.
Er zijn enkele kleine aandachtspunten die nog weggewerkt moeten worden, en als dat lukt, krijgen de wandelingen begin oktober de officiële erkenning als Europese kwaliteitswandeling.

2. NL_N_2

Sahara was ooit weelderig groen, blijkt uit rotstekeningen van 4.000 jaar geleden die vee afbeelden

(https://www.vrt.be/vrtnws/nl/2024/05/10/4-000-jaar-oude-rotstekeningen-tonen-hoe-de-sahara-er-vroeger-he/)
De kurkdroge Atbaiwoestijn in het oosten van wat vandaag Soedan is, moet enkele duizenden jaren geleden weelderig groen zijn geweest. Dat suggereren nu ook rotstekeningen in de regio die 4.000 jaar oud zijn en waarop onder meer vee is te zien.
De rotstekeningen zijn uitgebreid onderzocht tijdens veldwerk in de jaren 2018 en 2019. Julien Cooper van de Macquarie University in Australië leidde toen een team archeologen in het zogenoemde Atbai Survey Project, waarin 16 nieuw ontdekte rotstekeningen uit Wadi Haifa werden bestudeerd.
Vandaag is het een kurkdroge regio in het oosten van Soedan. Maar de tekeningen suggereren dat de omgeving er toen compleet anders uitzag. Er viel veel meer regen en het landschap zag er groen uit, weelderig groen zelfs, moet blijken uit de rotstekeningen waarop vee staat afgebeeld.
"Het was een raadsel om vee afgebeeld te zien op de wanden van rotsen midden in de woestijn, want voor het houden van runderen is veel water nodig, en weiland. Ze zouden in de Sahara van vandaag geen kans maken", zegt Cooper in een mededeling van de universiteit.
Volgens Cooper is de aanwezigheid van heel wat vee in de tekeningen "een van de belangrijkste bewijsstukken van een voormalige groene Sahara". Dat komt ook overeen met eerdere bevindingen van experts.
Groene Sahara? Eerder archeologisch en klimatologisch veldwerk heeft al aangetoond dat alvast een deel van de huidige Sahara in Afrika er vroeger totaal anders moet hebben uitgezien tijdens de zogenoemde "Afrikaanse natte periode".
[…]
Rond 3.000 voor Christus begonnen meren en rivieren uit te drogen en verdwenen ook de grazige weiden. De mensen trokken weg in de richting van de Nijl.

De aanwezigheid van mensen bij het vee suggereert dat de dieren gemolken werden. Er zouden herders geleefd hebben in het gebied, maar zij begonnen het rond 3.000 voor Christus moeilijker te krijgen.

"De bevolking trok weg en er waren hoogstens nog schapen of geiten. De impact op het leven moet groot geweest zijn", zegt Cooper.

De tekeningen tonen niet enkel vee. Er zijn ook boten afgebeeld. Die hebben speciale kenmerken in deze tekeningen, en waren misschien het werk van plaatselijke Nubische stammen.

3. NL_E_1

Achtergelaten in de woestijn om te sterven: ophef over Europese migratiedeal na foto van dode moeder en dochter

(https://www.vrt.be/vrtnws/nl/2023/07/28/tunesie-migratie-matyla-dosso-mbenge-crepin-marie/)

[…]

Het hartverscheurende beeld van een moeder en haar dochter, omgekomen in de woestijn na dagen zonder water, veroorzaakt wereldwijde verontwaardiging. Matyla Dosso (30), haar man Mbenge Crepin (29) en hun dochter Marie (6) hoopten op een beter leven in Tunesië, maar lokale autoriteiten hielden het gezin tegen en zonden hen terug. […]

Het koppel ontmoette elkaar in 2016 in een Libisch detentiekamp. Hij kwam uit Kameroen, zij uit Ivoorkust. Een jaar later kregen ze samen een dochtertje. Marie is sinds haar geboorte nog geen dag naar school geweest. "Dat was de grote droom van haar moeder. We wilden haar toekomst redden", klinkt het bij Mbenge Crepin, haar papa.

[…] Het gezin hoopte om in Tunesië een beter leven te vinden. Dat hun poging om het land binnen te geraken zo dramatisch zou aflopen, hadden ze nooit durven denken. […] "De politie sloeg ons met hun wapens en stuurde ons terug de woestijn in", getuigt Crepin.

Het gezin had al dagen niet deftig gegeten en gedronken. "Na een wandeling van een uur verloor ik het bewustzijn. Mijn vrouw en kind huilden. Toen ik bijkwam, smeekte ik om me achter te laten. Als ze bij me bleven, zouden we samen omkomen. Ze moesten proberen tot in Libië te geraken. Ze vertrokken en lieten me achter in de woestijn. Ik wist dat het voor mij bijna zou eindigen, want ik was nauwelijks nog aan het ademen."

Maar Crepin had geluk. Drie Soedanese migranten troffen hem aan in de woestijn en gaven hem water. […] Samen trokken ze naar de Libische grens, Crepin hoopvol dat hij daar zijn vrouw en kind zou aantreffen. Niets bleek minder waar. De rest van het gezin had de grens nooit bereikt.

Crepin vernam het nieuws op sociale media, waar een foto van zijn overleden vrouw en kind circuleerde. "Ik herkende ze meteen aan hun kledij", vertelt hij. "Ze lagen in exact dezelfde positie waarin ze soms slapen." De handen van Marie klampten zich vast aan het gele kleed van haar moeder. Crepin weet niet waar de lichamen juist werden aangetroffen. Hij wil hun stoffelijke resten zo snel mogelijk terugvinden, zelfs als dat betekent dat hij de gevaarlijke woestijn weer in moet.

[…]

4. NL_E_2

Nathalie (49) werd op de grond geslagen en verkracht tijdens het joggen: "Ik heb hem verteld hoe hij mij en mijn gezin kapot heeft gemaakt"

(https://www.gva.be/cnt/dmf20220227_93155459)

[…]

Nathalie Huygens (49) vertelt het allemaal heel sereen. Drie uur lang. Háár verhaal. Rauw en onverbloemd. […] "Na de feiten was heel mijn gezicht kapot. Mijn oogkas, mijn tanden, mijn kaak… Alles heeft hij gebroken. Ik ben helemaal kapotgeslagen. […]" […].

"Vóór de feiten ging ik al een jaar of twee elke dag hardlopen. Ik kreeg daar een kick van. Er ging geen dag voorbij dat ik het niet deed. Die zaterdag […] ben ik extra vroeg de deur uitgegaan. Het was nog donker."

"Eenmaal in het park hier verderop zag ik plots die gedaante op mij afkomen. Alles in mij zei: *Keer om, en kom later nog eens terug*. Maar ik had ook zoiets van: *Neen, ik wil gewoon lopen. Waarom zou ik niet doorlopen*? […]"

"Toen ik hem kruiste, leek die man compleet weg van de wereld. Helemaal in zichzelf gekeerd. Zwart van woede. Ik ben hem dan letterlijk echt voorbij gelopen en dacht dat hij weg was. Maar op het moment dat ik achterom keek, greep hij me bij mijn nek. […]"

"Dan greep hij mij vast en gooide hij me weg in een greppel naast het pad. Daar is hij mij beginnen te slaan. Ongelooflijk hard. Ik heb me verweerd tot en met. Je kan op dat moment niet anders. Je denkt zelfs niet na. Ik was ongelooflijk aan het krijsen, maar hij bleef maar inbeuken op mijn gezicht met zijn volle vuist. Plots kwam er één slag zo hard binnen dat ik besefte: *Als hij dat nog eens doet, ben ik dood*. Toen ben ik stilgevallen. En hoopte ik dat het gedaan was. Maar dan moest de hel nog losbreken. Ik kon niet meer ontsnappen. Hij zette nog een mes tegen me aan en hij is begonnen. Het was afgrijselijker dan hoe ik ooit had kunnen inbeelden dat zoiets gebeurt. Ik dacht dat hij nooit zou stoppen. Tot hij plots klaar was. En gewoon weg stapte. Heel traag. De donkere gedaante was ineens een ontspannen, rustige wandelaar geworden. Er was niets raar meer aan hem te zien. Weg was hij, terwijl ik daar voor dood werd achtergelaten."

[…]

5. EN_N_1

Photo-sharing app BeReal acquired by Voodoo for €500mn

(https://www.ft.com/content/2c1d3fa8-e3a8-48e3-b252-9b4059876412)

Photo-sharing platform BeReal has been scooped up by video game and app developer Voodoo for €500mn, in a French tie-up that comes as the government beefs up its technology ambitions.
Voodoo plans to launch paid advertising on BeReal in an effort to move the company towards profitability, its chief executive Alexandre Yazdi told the Financial Times, adding that it wanted to expand the company's active user base.
The takeover was advised by JPMorgan and is the biggest in Voodoo's history. Aymeric Roffé, head of Voodoo-owned social media app Wizz, will become chief executive of BeReal, while Alexis Barreyat, who founded the platform in 2019 aged 26, will remain "actively involved".
Jean de la Rochebrochard, a BeReal board member and partner at Kima Ventures, an investment company co-founded by French billionaire Xavier Niel, called the sale "a wise decision", especially as big financing rounds had become rarer while investors focused on the much-hyped artificial intelligence sector.
BeReal promotes authenticity on its platform in contrast to the filters and editing commonplace on rivals such as Snapchat and Instagram. The Paris-based tech company, however, has largely stagnated in terms of user growth since 2022 when its popularity surged among teenagers and young adults.
[…]
BeReal's monthly active users have held steady at about 50mn since the end of 2022, according to data from market intelligence company Sensor Tower. Downloads, however, tumbled from a peak of about 35mn in the third quarter of 2022 to 5mn in the three months to March this year.
"We think advertising is necessary for the business model of a social media platform," said Yazdi. He emphasised that adverts would be integrated in an "extremely fluid" format to avoid "damaging the user experience".
Rival platform Instagram, owned by Meta, introduced paid advertising in 2013, three years after it first launched.
[…]
Users can only see others' images after sharing their own, which Yazdi said made BeReal an "uncommon" social network where all users were actively engaged.

6. EN_N_2

Trump signals backing for Florida marijuana legalization

(https://www.bbc.com/news/articles/cq6rj3n8nrdo)

Donald Trump has signalled that he will vote in favour of legalising marijuana for personal use in his home state of Florida, ahead of a ballot on the issue in November.

The Republican presidential nominee wrote on his Truth Social platform that voters are highly likely to approve the measure "whether people like it or not" and therefore "it should be done correctly".

The former US president's stance puts him at odds with other senior Republican figures, including Florida Governor Ron DeSantis, who has argued that legalising recreational cannabis use would "be bad for quality of life".

Medicinal marijuana was made legal in Florida in 2016.

Cannabis for both personal and medical use is legal in 24 US states, according to the Pew Research Centre. A further 14 states have legalised medical marijuana.

Trump said: "Someone should not be a criminal in Florida, when this is legal in so many other states.

"We do not need to ruin lives and waste taxpayer dollars arresting adults with personal amounts of it on them."

The proposal is one of a number of amendments Florida residents will vote on in November at the same time as the US chooses its new president. Trump is running against incumbent vice-president and Democratic Party nominee Kamala Harris.

On legalising marijuana for personal use, Trump said that there would need to be rules in place to "prohibit the use of it in public spaces, so we do not smell marijuana everywhere we go, like we do in many of the Democrat-run cities".

Mr DeSantis has claimed that making cannabis legal for recreational use "would turn Florida into San Francisco or Chicago" - both cities in Democrat-run states.

Marijuana was legalised in Illinois 2020 and between January and July this year, cannabis sales reached more that $1bn (£760m), according to state government statistics.

In California, where personal use was legalised in 2016, marijuana sales reached $4.4bn last year. However, it is not clear how those figures compare to black market sales of cannabis which, according to some, still thrives.

[…]

7. EN_E_1

Mother reveals the heartbreaking moment she found her 13-year-old son dead in her yard after he fell victim to Snapchat sextortion scheme

(https://www.dailymail.co.uk/news/article-13462201/timothy-barnett-suicide-teenager-sextortion-snapchat.html)

[…]

Timothy Barnett's body was first discovered in the family's driveway in Sumter, about an hour outside of Columbia, by his step-father, Geoffrey Hauptman, around 6.30am on April 6, of last year.

Geoffery, who initially thought 'someone was sleeping in the yard,' quickly called his wife, Timothy's mother, Betsy Hauptman. In what became the worst moment of their lives, they realized Timothy had committed suicide.

About six months later, Betsy realized that Timothy had fallen victim to a Snapchat sextortion scheme, when an offender persuades a victim to send graphic videos and pictures online in exchange for money or more explicit content.

[…]

In a Facebook post about the horrifying loss of her son, Betsy said that just before he took his own life, Timothy 'sat in the driveway in the wee hours of the morning, pleading with someone on snapchat not to post something online.'

Initially, the local police department seized Timothy's iPhone and a Chromebook that was issued by his school, Alice Drive Middle School.

After accessing the teen's iCloud account, authorities discovered nearly a dozen drafted suicide notes written to Timothy's family and friends, as well as call history to a number with a New York area code.

Further investigation revealed that the number was sending Timothy links to Snapchat, and that the teen had another account, unknown to his parents, that was reportedly run by a stranger.

Under that account, police found that Timothy and a stranger were discussing a payment for $35 a day via the payment platform CashApp.

In return for the money, Timothy had asked the stranger to promise not to share a sexually explicit photo of him that he had shared on Snapchat.

Police discovered that the person that Timothy was messaging was pretending to be a woman and that his parents and his friends had no idea about their online interactions.

[…]

Despite finding a slew of evidence that linked Timothy to Snapchat, the Sumter Police Department closed the case and said that it was not their responsibility to figure out why Timothy decided to take his life.

[…]

8. EN_E_2

Woman describes horror of learning husband drugged her so others could rape her

(https://www.bbc.com/news/articles/cd9dwxexp77o)

[…]

Gisèle Pélicot, who is 72, was giving evidence on day three of the trial in Avignon, south-east France, of 51 men – including her husband of 50 years, Dominique. All are accused of rape.
Documents before court indicate that Dominique Pélicot, 71, admitted to police that he got satisfaction from watching other men have sex with his unconscious wife.
[…]
She recalled the moment in November 2020 when she was asked by police to attend an interview alongside her husband. He had recently been caught taking under-skirt photographs of women at a supermarket, and Gisèle told the court she believed the meeting with police was a formality related to that incident.
[…]
Police claim the men were given strict instructions. They had to park at some distance from the house so as to not attract attention, and to wait for up to an hour so that the sleeping drugs which he had given Gisèle could take effect.
They further claim that, once in the home, the men were told to undress in the kitchen, and then to warm their hands with hot water or on a radiator. Tobacco and perfume were not allowed in case they awoke Gisèle. Condoms were not required.
[…]
According to the investigation, Dominique watched and filmed the proceedings, eventually creating a hard-drive file with some 4,000 photos and videos on it. It was as a result of the upskirting episode that police found the files on his computer.
Police say they have evidence of around 200 rapes carried out between 2011 and 2020, initially at their home outside Paris, but mainly in Mazan, where they moved in 2013.
Investigators allege that just over half the rapes were carried out by her husband. Most of the other men lived only a few kilometres away.
[…]
After the truth emerged, Gisèle found that she was carrying four sexually-transmitted diseases.
“I have had no sympathy from any of the accused. One who was HIV-positive came six times. Not once did my husband express any concern about my health,” she said.
She is now in the process of divorcing him.
[…]

Appendix 3

	R_N_NL	R_N_EN	R_E_NL	R_E_EN
Mean Tonic EDA (µS)	7.41(2.6)	7.8(2.77)	7.90(2.38)	7.26(1.64)
Highest Tonic (µS)	8.55(3.07)	8.79(3.29)	9.35(3.02)	8.78(2.12)
Lowest Tonic (µS)	6.94(2.45)	7.21(2.57)	7.29(2.18)	6.65(1.51)
Highest Phasic (µS)	0.41(0.33)	0.5(0.26)	0.82(0.36)	0.74(0.34)
Lowest Phasic (µS)	-0.33(0.23)	-0.32(0.22)	-0.43(0.16)	-0.56(0.29)
Time (min)	1.20(0.15)	1.39(0.29)	1.24(0.14)	1.71(0.26)
SCR count	2.4(1.95)	2.2(1.3)	2.6(1.34)	4(1.22)
SCR/min	2.15(1.84)	1.60(0.5)	2.11(1.06)	2.33(0.5)
HR (bpm)	68.79(11.93)	67.51(13.08)	67.22(13.77)	63.91(10.33)
HRV (s)	0.91(0.16)	0.92(0.19)	0.89(0.13)	0.97(0.16)

Table 5. Averages of the physiological variables collected during the reading tasks excluding the potential outlier. SDs in parentheses.

	T_N_NL-EN	T_N_EN-NL	T_E_NL-EN	T_E_EN-NL
Mean Tonic EDA (µS)	7.24(2.42)	7.49(2.5)	7.94(2.26)	6.84(2.23)
Highest Tonic (µS)	9.68(3.3)	10.16(3.68)	10.5(2.66)	9.48(2.19)
Lowest Tonic (µS)	6.38(2.18)	6.62(2.26)	7.14(2.09)	6.06(2.1)
Highest Phasic (µS)	0.86(0.36)	1.04(0.56)	1(0.51)	0.74(0.39)
Lowest Phasic (µS)	-0.77(0.48)	-0.94(0.69)	-0.82(0.38)	-0.74(0.33)
Time (min)	14.58(2.84)	17.94(5.36)	15.54(3.97)	16.79(5.88)
SCR count	30.6(16.09)	36.6(14.38)	40.2(17.54)	30.8(26.54)
SCR/min	2.04(0.81)	2.1(0.77)	2.6(1.11)	1.748(1.19)
HR (bpm)	71.93(12.18)	72.99(14)	72.49(15.48)	70.22(10.95)
HRV (s)	0.86(0.15)	0.85(0.16)	0.86(0.18)	0.88(0.14)

Table 6. Averages of the physiological variables collected during the translation tasks excluding the potential outlier. SDs in parentheses.

Appendix 4

	R_N_NL	R_N_EN	R_E_NL	R_E_EN
Mean Tonic EDA (µS)	8.58(3.69)	8.9(3.66)	8.78(2.97)	8.89(4.26)
Highest Tonic (µS)	10.11(4.71)	10.8(5.72)	10.96(4.78)	10.71(5.08)
Lowest Tonic (µS)	7.93(3.26)	8.01(3.01)	7.95(2.53)	7.70(2.92)
Highest Phasic (µS)	0.58(0.52)	0.99(1.23)	1.32(1.26)	1.09(0.9)
Lowest Phasic (µS)	-0.45(0.36)	-0.71(0.96)	-0.69(0.65)	-1.25(1.73)
Time (min)	1.25(0.18)	1.8(1.03)	1.26(0.13)	1.51(0.53)
SCR count	3(2.28)	4.5(5.75)	2.83(1.33)	3.67(1.37)
SCR/min	2.46(1.8)	2.03(1.3)	2.26(1.02)	2.57(0.75)
HR (bpm)	69.31(10.75)	67.13(11.73)	67.03(12.32)	65.97(10.52)
HRV (s)	0.9 (0.15)	0.93(0.17)	0.89(0.11)	0.94(0.16)

Table 7. Averages of the physiological variables collected during the reading tasks. SDs in parentheses.

	T_N_NL-EN	T_N_EN-NL	T_E_NL-EN	T_E_EN-NL
Mean Tonic EDA (µS)	8.52(3.82)	8.55(3.44)	8.9(3.1)	8.12(3.71)
Highest Tonic (µS)	11.51(5.37)	11.7(5)	12.44(5.32)	11.21(4.66)
Lowest Tonic (µS)	7.50(3.38)	7.55(3.04)	7.79(2.46)	7.10(3.17)
Highest Phasic (µS)	1.28(1.06)	1.3(0.81)	1.38(1.02)	1.01(0.748)
Lowest Phasic (µS)	-0.97(0.65)	-1.07(0.69)	-1.15(0.86)	-0.88(0.47)
Time (min)	15.71(3.76)	18.02(4.8)	17.19(5.38)	17.53(5.56)
SCR count	42(31.41)	43.67(21.57)	53.33(35.8)	46.17(49.59)
SCR/min	2.47(1.28)	2.46(1.13)	2.94(1.3)	2.47(2.07)
HR (bpm)	71.95(10.9)	72.05(12.73)	72.27(13.85)	69.91(9.83)
HRV (s)	0.86(0.13)	0.86(0.15)	0.86(0.16)	0.88(0.13)

Table 8. Averages of the physiological variables collected during the translation tasks. SDs in parentheses.