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*Article*

# Laying the Conceptual Groundwork for OESEL: The Ontology of English and Sinhala Emotion Lexicon

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**Abstract**

Perceiving and articulating emotions are fundamental aspects of human existence. However, given their abstract nature, emotions are often nuanced and challenging to express. Conveying emotions across languages and cultures can be particularly difficult. Although individual emotion words may have equivalents in other languages, translating the contexts in which emotions are expressed is rarely straightforward. This presents a barrier to fully understanding spoken and written communication across linguistic communities. In addition to hindering interpersonal communication, this limitation can reduce the accuracy of language technologies and translation tools. This study explores the conceptual foundations for an ontology of emotion words in English and Sinhala. The ontology is titled OESEL, the Ontology of English and Sinhala Emotion Lexicon. The paper outlines the design of the ontology and assesses the feasibility of the proposed architecture with illustrative examples. We argue that a cross-linguistic ontology of emotion lexicon can provide a more grounded and meaningful mechanism for identifying and retrieving emotion words and concepts across languages.

**Keywords:** information retrieval; multilingual and cross-lingual retrieval; emotion semantics; Sinhala language

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## 1. Introduction

Emotions are integral to human existence and are perceived and expressed in a wide variety of contexts. However, emotions can also be difficult to understand and convey. A key challenge in researching emotions is their abstract nature. While humans feel emotions, they are often expressed using approximate labels. For instance, we can say *chair* and point to a chair, but we cannot say *joy* and point to the feeling. *Joy* is merely a label to express a certain state of mind. This complication is further compounded when exploring emotion expression in cross-linguistic settings.

Driven by key questions around this idea of cross-linguistic emotion semantics, our previous work sought to explore the factors that impact the perception of similar emotions across Sinhala and English (Sinhala is an official language of Sri Lanka). We utilised a Synonym Rings (SRs)-based approach to map emotion lexicon of the two languages and their deviations (Alahapperuma and Vlachidis, 2025). This initial study shed light on some key features of the Sinhala language that impact the way emotional content is conveyed and perceived. Diglossia and the influence of religious terminology are two such features. We believe that continuing along these lines of inquiry will provide more meaningful insights and approaches to understanding cross-language emotion semantics. Further, Sinhala is a low-resource language. It is under-served by the latest language technologies. Therefore, extending our initial work to a more generalised investigation in emotion semantics is likely to provide the understanding and frameworks to better cater to low-resource languages.

However, we also observed that discourse analysis and SRs alone do not provide sufficient methodological rigour to scale our work. As a result, in this study, we explore the foundations to extend the initial SRs-based emotion word representation system to an ontological system. The primary purpose of such a mapping is to understand whether an organised body of emotion lexicon can function as a framework to enrich current language technology and translation tools. We want to explore emotion lexicon as "things, not strings" (Singhal, 2012), by moving beyond treating emotion terms as mere labels and working towards encoding more contextual information to encapsulate subtle nuances that emotions carry. In doing so, our aim is to seek answers to the following research questions:

(1) How can cross-linguistic emotion semantics between English and Sinhala be represented formally in an ontology of emotion lexicon?

(2) To what extent can such an ontology capture the cultural and linguistic nuances of a low-resource language such as Sinhala, and support the retrieval of emotion terms and their contextual properties?

A cross-linguistic emotion lexicon ontology could serve as the semantic backbone of translation tools for low-resource languages.

The remainder of this paper is organised as follows: In section 2, Related Work, we look at relevant literature to situate our work within the broader research context; in section 3, Methodology, we discuss our methodological approach; in section 4, Developing the Synonym Rings, we provide relevant context regarding our initial SRs-based inquiry; in section 5, Conceptual Framework and the Architecture of the Ontology of English and Sinhala Emotion Lexicon, we provide the theoretical framework and details of implementation for the ontology; in section 6, Conclusions, Limitations, and Further Applications, we present the known limitations of our work and directions for further research.

## 2. Related Work

This section evaluates relevant literature, specifically within linguistics, psychology, and knowledge organisation.

Research on emotions and the meaning of emotions ranges across a wide range of disciplines. From philosophy to computer science, various scholars have attempted to understand the phenomenon of emotions that is core to human existence (Chin et al., 2021; Khare et al., 2024; Kurth, 2022; Lange et al., 2020; Ortony, 2022). However, despite the many efforts made, Fox (2018) writes that there may not exist a "scientific consensus on the fundamental nature of emotions".

### *2.1 Emotions, Language, and Multilingualism*

There is a growing body of research exploring the idea that language shapes the way humans perceive emotions (Heelas, 2024; Hoemann et al., 2019; Lindquist et al., 2015). In early work, Wierzbicka (1995) explores the theoretical foundations underlying emotions and multilingualism. Wierzbicka questions, "Why should human psychology be interpreted through the prism of English rather than through that of other languages?".

Jackson et al. (2019) note that a language can have unique emotion vocabulary, for which there might not be equivalent terms in other languages. For instance, their work points out that "the German word *Sehnsucht* refers to a strong desire for an alternative life and has no direct translation in English". This observation raises interesting questions. Does the lack of a term imply that the emotion concept *Sehnsucht* will not resonate with English speakers? How can the idea *Sehnsucht* be conveyed to speakers of English? Since the English term does not exist, then does it mean that English speakers cannot fathom the feeling *Sehnsucht* at all?

Further work on the topic extends the idea that emotions and emotion expression can vary across cultures and languages (Gendron et al., 2014; Jack et al., 2012; Ponsonnet, 2014).

Preliminary readings by Jackson et al. (2019), Chin et al. (2021), Wierzbicka (1995), and others reveal vari-

ous factors that influence how emotions are perceived and conveyed. We identify the psychology of emotions, the features of a language, and sociocultural aspects within a language community as three key factors that impact emotion perception. We note that each individual's perception of a given emotion term will be a combination of the above three factors.

### *2.2 Psychological Models of Emotions*

Expanding the SRs to an ontological representation requires a greater understanding of the nature of emotions. There are several psychological models and theories of emotions. We summarise some of the key readings below.

#### 2.2.1 Theories of Basic Emotions

Ekman (2004) proposes that there are certain basic emotions that are biological and universally identified. Theories by Panksepp suggest that there are seven primary emotion systems in the mammalian brain (Davis and Montag, 2019; Panksepp, 2004). Interestingly, Ekman (2004, p. 30) writes:

> … there are a few psychologists, primarily those concerned with language, who complain that our work in literate cultures, where we asked people to identify the emotion word that fit the expressions, does not support universals since the words for each emotion don't have perfect translations.

Our work towards a cross-linguistic emotion ontology aims to explore a way to cohesively bridge the gap between psychological theories put forward by psychologists such as Ekman, along with the literary and linguistic approaches of naming emotions.

#### 2.2.2 Hierarchical Models of Emotions

While basic theories of emotions present the notion of universal and fundamental emotions, we want to explore this idea further to understand more comprehensive frameworks around universal emotions.

The circumplex model of affect proposed by Russell uses two axes to represent emotions on a two-dimensional plane (Posner et al., 2005; Russell, 1983). The system uses two metrics, valence (pleasant-unpleasant continuum) and arousal (arousal-sleep continuum), as the two dimensions of the plane, and maps emotions as a linear combination of these two metrics (Barrett and Russell, 1998).

Parrott (2001) proposes a model of emotions that goes beyond two categories and maps emotions along a tree structure. In this model, there are levels of emotions, primary, secondary, and tertiary.

Plutchik's work advances these models of emotion by bringing in additional dimensions of emotions. Plutchik notes that emotions vary by intensity, similarity, and polarity, and presents this model in a three-dimensional layout (Plutchik, 1970). In the layout proposed by Plutchik (1970), emotions change intensity along the vertical axis of a cone, where emotion terms that are on opposite sides of the cone display strong polarity. Emotions close to each other in the cone show similarity. These three dimensions can be used to place a given emotion term on a point in the conical space, providing a methodical approach to mapping emotions in a more complex web, while acknowledging that "it is important to note that the words used are only approximate terms borrowed from the introspective language" (Plutchik, 1970). We refer readers to Figure 1 provided by Plutchik (1970, p. 10) in *Emotions, Evolution And Adaptive Processes* for further details on this three-dimensional layout.

### *2.3 Methodological Approaches to Representing Emotions*

Research in the field of emotions takes different approaches to selecting, analysing, and synthesising emotion concepts and terms. We evaluated various Knowledge Organisation Systems (KOSs) to identify a suitable information representation system for our work. Zeng (2008) does a detailed mapping of different KOSs and how they can be used to denote various relationships among words. A KOS with sophisticated features provides greater functionality, while more simplistic systems may work better to serve a specific purpose. For instance, a glossary or a dictionary can eliminate ambiguity in representing semantic information, but is constrained in representing relationships between terms. A taxonomy is able to provide hierarchical relationships between terms, while being constrained in terms of the information that can be provided about the associative relationships between terms (Zeng, 2008).

For our purpose, that is, representing information about emotions across languages and cultures, the KOS needs to be able to convey the complex and often ambiguous relationships between synonymous emotion terms and concepts. However, emotion categories do not have well-defined boundaries, and they do not have an inherent hierarchy. The KOS needs to work with these demands of representing emotions.

#### 2.3.1 Synonym Ring-Based Representation of Emotions

In referencing SRs, Zeng notes that "the rings also contain terms that are more general or specific than other terms on the ring". Since emotion words and their synonyms are ideally a set of "equivalent yet different" collection of terms, SRs are a suitable KOS to depict the semantic relationship of emotion lexicon. As such, our work starts by using SRs to map the conceptual arrangements and semantic variability of emotions. We believe SRs provide a useful foundation to draw initial relationships between semantic concepts, which we can then extend to a robust system of emotion lexicon for further evaluation.

#### 2.3.2 Ontological Representations of Emotions

While SRs are ideal to understand and evaluate emotion concepts at a granular and conceptual level, SRs are not scalable. This is a significant limitation if we are to draw inferences from a large body of emotion lexicon. As a result, we want to explore higher functional and structural systems as a more scalable approach to knowledge organisation.

The rationale for building an ontology of emotion lexicon comes from the fundamental purpose of an ontology itself. Formal ontologies allow users to make logical deductions. For example, an ontology of animals can deduce that a white and black striped animal is a zebra (Jean-Baptiste, 2021). Similarly, we believe that a cross-linguistic ontological representation of emotion lexicon will allow us to use logical deductions to arrive at similar emotions across languages with greater accuracy. For instance, drawing from the psychological foundations of emotions discussed in section 2.2, with the use of concepts such as triggers, intensity, and physical manifestations of an emotion, we may be able to conclude that a given emotion term in English best coincides to a specific emotion term in Sinhala. This is a much more precise mapping than settling for a mere label that is arrived at via social convention or habit.

To understand the feasibility of developing an ontology of emotion lexicon, we looked at work available on ontologies related to emotions, emotion expression, and emotion annotation. We summarise some of the relevant and representative work below.

Tabassum and Ahmed (2016) discuss their work on EmotiOn, an ontology for emotions. The primary purpose of their work is to build an ontological model based on Plutchik's wheel of emotions. EmotiOn derives the classes, properties, and relationships from Plutchik's wheel of emotions, with a broader goal of emotion evaluation via ontologies.

Kim and Klinger (2018) have developed Relational EMotion ANnotation (REMAN), a text corpus based on the Project Gutenberg. The authors note that text-based emotion analysis is overly simplified and produces overgeneralised results, without full consideration of the subject of the emotion. To correct for this oversimplification, REMAN compiles a literary text dataset, where phrases are annotated based on the emotion, the experiencer, and the target and the cause of the emotion. REMAN is also based on Plutchik's wheel of emotions. Our thinking on the limitations of purely text-based analysis of emotions aligns well with, and is further established by, the ideas proposed by Kim and Klinger (2018).

Lin et al. (2017) use Ekman's model of emotions and the revised Ortony, Clore, and Collins' model of emotions (revised OCC model) to develop the Visualized Emotion Ontology (VEO). Contrary to the application scenario of most emotion ontologies, VEO is built with the intention of improving the interactions between healthcare providers and patients in clinical settings. The ontology builds the semantic definitions of 25 emotions along with a visual representation of these emotions. While the practical applications of VEO are different to what we wish to explore, the approach to developing VEO provides valuable insight into our work.

These studies establish the feasibility of developing an ontology based on emotion concepts and labels. They have also been successfully utilised for different use cases such as sentiment analysis and literary analysis, and in clinical settings, providing evidence that such an ontology can be of wide-spread practical value. An outline of all emotion ontologies we surveyed is available in Table 1.

Based on these readings, our study proposes the design and development of the Ontology of English and Sinhala Emotion Lexicon (OESEL). OESEL aims to enable a formal representation of emotion lexicon between English and Sinhala and facilitate inference and deductions in relevant emotion semantics. The main features of OESEL are shown in Table 2, and are structured similar to Table 1 for ease of comparison. Section 5 of this paper details the architecture, design choices, and proof of concept of the proposed ontology.

While Table 1 captures a variety of ontologies with different conceptual and implementation mechanisms, we emphasise that OESEL is envisioned and implemented as an ontology of emotion lexicon, and not as an ontology of emotion concepts. OESEL aims to put together a mechanism to map emotion words across different languages, while situating the terms within broad emotion categories derived from the psychological models of emotions.

To provide further theoretical grounding to our work, we draw from lemon, Lexicon Model for Ontologies (https://lemon-model.net/). Although lemon is not specifically built to model emotions, lemon provides valuable insights into modelling lexicon using ontologies. We have discussed this further in the methodology section.

### *2.4 Researching the Semantics of Emotions Within the Constraints Presented by a Low-Resource Language*

While the primary objective of our work is to explore the semantics of emotion across Sinhala and English, we also want to note the resource constraints encountered when working with Sinhala. Even though Sinhala is an official language of Sri Lanka, and is therefore well-supported and widely used within Sri Lanka, it is under-resourced in the global linguistic landscape. There are significant challenges in using computational tools and emerging language technologies with Sinhala. This is due to the limited availability of language data and low compatibility with computational tools.

Various facets of working with low-resource languages are covered by scholars across the globe. El-Haj et al. (2015) emphasise the importance of language resources to execute computational methods to study languages. Referencing the Arabic language, the authors note the absence

**Table 1. A survey of ontologies that map emotions and emotional content.**

| | |
|---|---|
| **EmotiOn** (Tabassum and Ahmed, 2016) | |
| Foundations | Plutchik's wheel of emotions |
| Languages | English |
| Use case | Sentiment and emotion analysis |
| Key features | Ontology includes classes, properties, and relationships |
| | Built for structured sentiment inference |
| | OWL-based implementation |
| **TONE** (Gupta et al., 2025) | |
| Foundation | Parrott's hierarchy of emotions |
| Languages | English |
| Use case | Emotion detection, product reviews, and empathetic response generation |
| Key features | Three-tiered emotional structure |
| | Includes intensity levels |
| | Designed for emotional text classification tasks |
| **Visualized Emotion Ontology (VEO)** (Lin et al., 2017) | |
| Foundation | Ekman's model of emotions and the revised Ortony, Clore, and Collins' model of emotions (The OCC model) |
| Languages | English |
| Use case | Application in clinical settings to improve healthcare practitioner-patient interactions |
| Key features | Provides the semantic definition of 25 emotions |
| | Develops a visual representation of the emotions |
| **Emotion Frames Ontology (EFO)** (De Giorgis and Gangemi, 2024) | |
| Foundation | Ekman's basic emotions and DOLCE foundational ontology |
| Languages | English |
| Use case | Ontology-driven reasoning and modular emotion networks |
| Key features | Emotions modelled as semantic frames |
| | Roles include experiencer, cause, and target |
| | OWL-based, supports automated inference |
| **Ontology for text annotation** (Mathieu, 2005) | |
| Foundation | Literary annotation of emotion categories |
| Languages | French |
| Use case | Annotating emotional content in fiction |
| Key features | Manual emotion phrase annotation |
| | Focused on emotion expression in literature |
| **REMAN Corpus** (Kim and Klinger, 2018) | |
| Foundation | Plutchik's wheel of emotions and literary texts from Project Gutenberg |
| Languages | English |
| Use case | Literary analysis |
| Key features | Creates a literary text corpus that provides relational data on emotions, experiencers, and cause |
| | Explores experimental applications such as coarse-grained emotion classification (i.e., understanding what the feeling is) and fine-grained emotion and role detection (i.e., understanding who is feeling the emotion and the underlying causes) |

OWL, Web Ontology Language; TONE, 3-Tiered ONtology for Emotion analysis; DOLCE, Descriptive Ontology for Linguistic and Cognitive Engineering; REMAN, Relational EMotion ANnotation.

of capitalisation in Arabic as an intrinsic feature of the language that makes the creation of resources challenging. They also note that Arabic corpora have shown "a bias towards religious terminology".

Points of comparison from Arabic provide some useful linguistic features to bear in mind, as we work with Sinhala. For instance, the Sinhala language is influenced by Buddhist concepts and terminology (Ariyawansa, 2014). Sinhala also has its own script with features different to

**Table 2. Key characteristics of the proposed OESEL ontology.**

| Proposed OESEL ontology | |
|---|---|
| Foundation | Based on the psychological models of Plutchik and Russell. Expands synonym rings (SRs) to capture linguistic elements of emotion lexicon alongside the psychological foundations. |
| Languages | Sinhala and English |
| Use case | Bilingual emotion mapping, translation, and low-resource NLP |
| Key features | A cross-linguistic emotion ontology<br>Aims to cover linguistic and sociolinguistic properties such as diglossia and religious terminology<br>Supports logical inference of emotions across languages via established psychological metrics of emotion |

OESEL, Ontology of English and Sinhala Emotion Lexicon; NLP, Natural Language Processing.

English. We want to ensure that the knowledge representation systems we build for Sinhala and English have the space to capture these nuances and differences. Further, we will examine and incorporate any features that are unique to the Sinhala language to OESEL to ensure that the semantic variations provided via linguistic aspects are encapsulated.

Now that we have evaluated relevant literature, specifically within the frames of linguistics, psychology, and knowledge organisation, we proceed to section 3 to detail our methodology for the study.

## 3. Methodology

Our research includes four stages, from the selection of text corpora to the development of the architecture and proof of concept of the ontology. The first three stages were originally presented in our previous work, where we used SRs to map the semantics of emotions in Sinhala and English (Alahapperuma and Vlachidis, 2025). However, as noted earlier, we observed that SRs do not provide sufficient scalability to expand our work. As a result, in this study, we specifically draw insights from our previous work to expand the SRs-based representation to an ontological one. The choice of an ontology is motivated by the functional capacity ontologies provide. One of the key drivers is that ontologies are based on formal logic, thereby providing an avenue to develop a formalised body of knowledge around the semantics and lexicon of emotion. While it may seem counterintuitive to introduce formal logic to feelings, the entire premise of our work is to explore the extent to which such a knowledge model can be conceptualised.

Another benefit of using an ontology is that ontologies are able to precisely capture various relationships, including features of relationships such as hierarchy, symmetry, and union. We are also able to use reasoners with an ontology, which enables us to check for logical consistency of the relationships we would draw between psychological, linguistic, lexical, and other elements in the emotion ontology. We are also very much motivated by the interoperability of ontologies. We can integrate our ontology into other knowledge and language representation systems, enabling us to draw more complex insights.

We outline further details of each of the steps below:

### *3.1 Selection of Text Corpora*

As the goal of this study is to lay the conceptual groundwork for OESEL, we utilise the same English text and its Sinhala translation as we did in our previous work, as the text corpus. This contained scope enables us to investigate deeper into the nature of the ontology that we want to build, without having to grapple with the complexities of textual analysis for a large corpus. We selected The Alchemist by Coelho (2002) for analysis as it contains a significant body of emotion words. There is a published version of The Alchemist in Sinhala, which made the text further suitable for our work. We particularly selected a text that had a published Sinhala translation, because this implies that the Sinhala text used for analysis would have gone through a reliable editorial process. The Sinhala translation is titled සාන්තියාගෝ නම් සැරිසරන්නා (*Santhiyago Nam Sarisaranna)*, translated by Chulananda Samaranayaka and published by Vidarshana Publishers (Samaranayaka, 2020). The English version of the Alchemist itself is a translation from Portuguese, where the English edition we used was translated by Alan R. Clarke, published by HarperCollins in 2002. We do not think that selecting a translated text impacts our analysis or conclusions, because the English text is a standalone literary work on its own.

We particularly decided to work on an English text and its Sinhala translation, instead of using an original text in Sinhala, because initial explorative work such as selecting key words was more practical to carry out and communicate in English. For instance, it is easier to talk about the emotion *love* using its English keyword, because the term *love* is easier to convey to readers who are reading this work in English.

### *3.2 Selection of Key Emotion Terms and Synonyms*

By using Voyant Tools (https://voyant-tools.org/; Voyant Consortium, initially hosted by the University of Alberta, Edmonton, Alberta, Canada), an online text analysis tool, three key emotion terms, *happy*, *love*, and *desire*,

were extracted from The Alchemist, in both Sinhala and English. The three key terms were selected based on their frequency of occurrence. The three terms are the most frequently occurring emotion terms in the English version of the text. Further, we decided to select the root form of the emotion term and avoided other variants and derived terms (for example, *happiness*, *loved*, *desirable*). We have also avoided emotion-related words and emotion-laden words (Pavlenko, 2008).

As noted in section 2.4, working within the constraints presented by a low-resource language brought about a set of challenges in text analysis. Tools that provided refined functionalities were often not equally compatible with Sinhala and the Sinhala script. Voyant Tools was specifically chosen because it provided a set of plug-and-play tools that supported Sinhala as well as it did English.

After selecting the set of key words, we developed a set of English and Sinhala synonyms for each key word. For each key word, synonyms for English were obtained from WordNet (https://wordnet.princeton.edu/) and Sinhala synonyms were taken from the Madura Online dictionary (https://www.maduraonline.com/). Here, WordNet and Madura Online were selected because they are well-known and widely used lexical resources that cover sufficient breadth of the languages. However, depending on the selected lexical resource, the list of synonyms extracted would vary to some degree. The synonym list we obtained via WordNet and Madura Online was sufficiently robust for us to progress with the methodology, and hence we have resorted to those as underlying lexical resources. Additional discussion on the limitations of this choice is included in section 6.1 of this paper.

### *3.3 Creation of Synonym Rings and Drawing Insights*

Combining the key words and sets of synonyms, we created an SR for each English and Sinhala key word. A numbering system is used to map the synonyms across the two languages, where the set of synonyms within the same semantic field across the two languages is represented by the same number.

We then use the SRs and insights derived from the SRs to understand the overlaps and deviations in the emotion lexicon of the two languages.

### *3.4 Exploring Ontological Representations for the Semantics of Emotion Across English and Sinhala*

In this step, we bring together the researched knowledge of the psychological theories of emotions and the findings and conclusions from the SRs to explore the architecture and implementation of OESEL. Based on readings and the requirements for scalability, we believe an ontological representation of emotion lexicon will provide us with a meaningful representation and a retrieval mechanism.

Now that we have looked at the methodological approach to our work, we proceed to section 4 to look at the implementation of the SRs and relevant insights.

## 4. Developing the Synonym Rings

This section covers the details of the development of the SRs and the observations derived from the SRs-based evaluation of emotion lexicon.

### *4.1 Synonym Rings for Happy*

Fig. 1 gives the Sinhala and English SRs for *happy*. The same SRs can be alternatively represented in tabular format, as shown in Table 3.

In Fig. 1, WordNet included four synonyms for *happy*, which represented four different fields of meaning. In the English SR, each of these words is given a number. For the Sinhala SR, the term සතුටු (*Sathutu*) was used as the headword. It is the most commonly used word in Sinhala to convey the emotion concept *happy*. In the Sinhala SR, we have given each term a number between 1 and 4, to correspond to one of the four meaning fields in the English SR. There were three Sinhala terms (numbered 5 and 6) which did not have an appropriate semantic field in the English SR.

Two of these terms සැප (*Sapa*) and සැපවත් (*Sapawath*), can be vaguely mapped to the concept *luxurious*. The Sinhala SR for *happy* includes the term මුදිත (*Muditha*) which has Buddhist religious connotations of *delight* (entry number 5 in the SR).

### *4.2 Synonym Rings for Love*

Table 4 gives the SR entries for *love*. In this section, we only provide the tabular format.

In this SR, *love* is used as the headword. In the Sinhala SR, we use ආදරය (*Aadaraya*) as the headword, because it is the generic Sinhala term used to convey the concept *love*. WordNet has ten synonyms for *love*, as shown in the left column of Table 4. These ten synonyms fell into nine semantic fields. While the Sinhala SR had more terms than the English one, most of these terms fell into the same semantic field as the terms in the English SR.

There are some unique terms in both SRs. For instance, *love* in English could mean *a score of zero in tennis or squash*, which had no equivalent term in Sinhala, and it is also not an emotion concept. The SR for Sinhala contains the term මෛත්‍රිය (*Maithriya*), which is a term with Buddhist religious connotations of *compassion* or *benevolence*. The Sinhala entries also include some words that are not widely used, which were difficult to place in a semantic field. However, all terms have been added to the SRs to capture all entries available in WordNet and the Madura Online dictionary.

### *4.3 Synonym Rings for Desire*

Table 5 provides the entries of the SRs for *desire*. In this section, we only provide the tabular format.

The Sinhala SR for *desire* had several entries compared to the English SR. Particularly, the concept *want* had multiple Sinhala terms. The Sinhala SR also had a

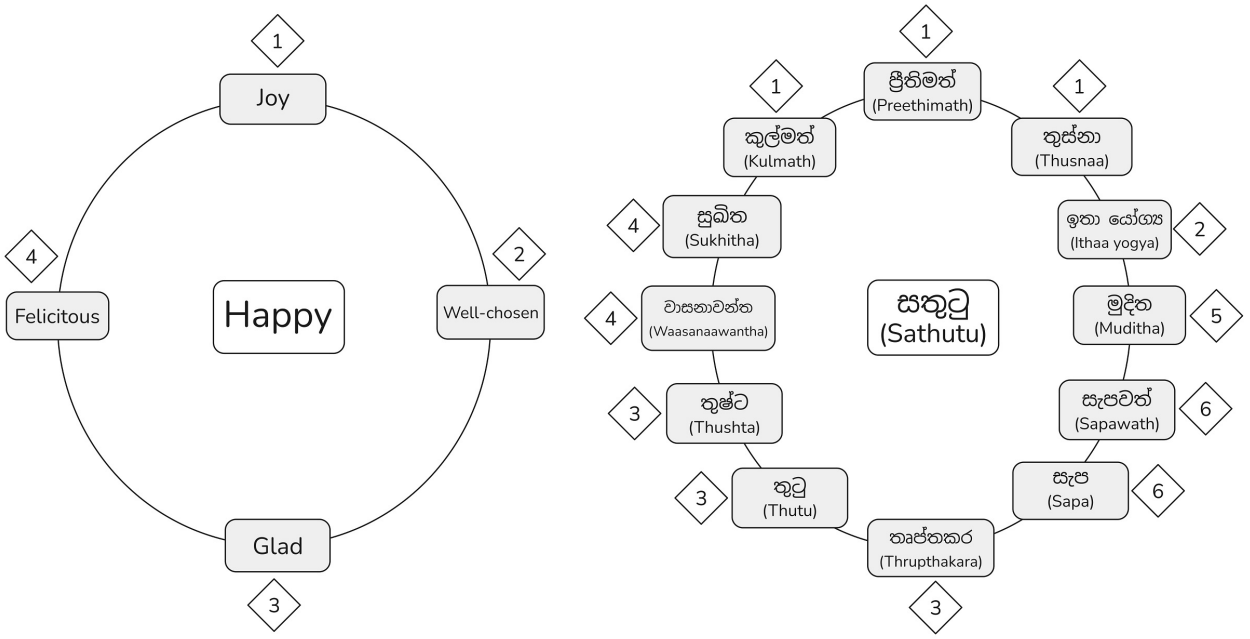


**Fig. 1. Synonym rings for *happy*.** On the left are the English synonyms for *happy*, presented as a synonym ring. On the right are the Sinhala synonyms for *happy*, presented as a synonym ring.

**Table 3. Tabular representation of the synonym rings for *happy*.**

| English | Sinhala |
|---|---|
| Joy | ප්‍රීතිමත් (*Preethimath*), කුල්මත් (*Kulmath*), තුස්නා (*Thusnaa*) |
| Glad | තෘප්තකර (*Thrupthakara*), තුටු (*Thutu*), තුෂ්ට (*Thushta*) |
| Well-chosen | ඉතා යෙහෙස (*Ithaa yogya*) |
| Felicitous | වාසනාවන්ත (*Waasanaawantha*), සුඛිත (*Sukhitha*) |
| No equivalent English entry. Both of these terms overlap with the English term *luxurious*. | සැපවත් (*Sapawath*), සැප (*Sapa*) |
| No equivalent English entry. This term overlaps with the English term *delight*. | මුදිත (*Muditha*) |

**Table 4. Tabular representation of the synonym rings for *love*.**

| English | Sinhala |
|---|---|
| Be in love | පෙමෙ (*Pema*),ප්‍රේමය (*Premaya*), ආලය (*Aalaya*) |
| Enjoy | ඇල්ම (*Alma*), ඇලුම් කරනවා (*Alum karanawaa*), ප්‍රිය කරනවා (*Priya karanawaa*) |
| Have affection for | ආදරය දක්වනවා (*Aadaraya dakwanawaa*), ආදරය කරනවා (*Aadaraya karanawaa*) |
| Regard or affection | ස්නේහය (*Snehaya*), සාදරය (*Saadaraya*),සනෙහෙස (*Senehasa*), දයාව (*Dayaawa*) |
| Any object of affection or devotion | ආලය කරන වස්තුව (*Aalaya karana wasthuwa*) |
| Sexual desire | නුරා (*Nuraa*), රති (*Rathi*), ශෘන්ගාර (*Shrungaara*) |
| Beloved person | පෙමේවතිය (*Pemwathiya*) |
| Make love, sexual activities | *No equivalent Sinhala term* |
| Score of zero in tennis or squash | *No equivalent Sinhala term* |
| No equivalent English entry | මෛත්‍රිය (*Maithriya*) |
| No equivalent English entries. These terms are not in common use. | ප්‍රාණය (*Praanaya*), සනා (*Sanaa*) |

**Table 5. Tabular representation of the synonym rings for *desire*.**

| English | Sinhala |
|---|---|
| Want | රුසි (*Rusi*), රිසි (*Risi*), අභිරුචිය (*Abhiruchiya*), කැමැත්ත (*Kamaththa*), අභිලාෂය (*Abhilaashaya*), ආසාව (*Aasaawa*), පිරිය (*Piriya*), කැමති වනෙවා (*Kamathi wenawaa*), අභිමානය (*Abhimaanaya*), මනරථය (*Manorathaya*) |
| An inclination to want things | තණ්හාව (*Thanhaawa*), තෘෂ්ණාව (*Thrushnaawa*), ලෝභ (*Lobha*), ලෝභ (*Loba*), ඇලියාව (*Aaliyaawa*) |
| Hope | අටිය (*Atiya*), අපේක්ෂාව (*Apekshaawa*), අභිප්රාය (*Abhipraaya*), පතනවා (*Pathanawaa*) |
| Express a desire for | ආසා කරනවා (*Aasaa karanawaa*), ඉල්ලා සිටිනවා (*Illaa sitinawaa*) |
| The feeling that accompanies an unsatisfied state | දෝළා (*Dola*), දෝලනවා (*Dolanawaa*), මනදෝළා (*Manadola*) |
| Something that is desired | *No equivalent Sinhala term* |
| A term for *sexual desire*. No equivalent English entry. | කාමය (*Kaamaya*) |
| No equivalent English entries. These terms are not in common use. | පුලනවා (*Pulanawaa*), තුස (*Thusa*), කලිමලි (*Kalimali*), ඉච්චාව (*Ichchaawa*) |

unique entry, the term කාමය (*Kaamaya*), which commonly conveys *sexual desire*. Further, similar to the Sinhala SR for *love*, the Sinhala SR for *desire* also includes a few terms that are not in common use, which could not be placed into a semantic field. As with the other SRs, the Sinhala SR for *desire* also included terms such as ලෝභ (*Lobha*) and තණ්හාව (*Thanhaawa*) which are predominantly Buddhist religious terms used to address concepts of *attachment*.

### *4.4 Observations From the Synonym Rings*

Based on the findings of the SRs, the following three key trends were observed regarding the emotion lexicon of English and Sinhala:

#### 4.4.1 The Impact of Diglossia

Sinhala is a diglossic language with two varieties: a high variety and a low variety. The use of these varieties depends on the context of usage. The high variety commonly appears in the formal and ceremonial use of Sinhala. The low variety appears more commonly in informal and spoken use of the language (Cardona and Jain, 2003, p. 21). We observed this feature in the analysis of The Alchemist. For instance, in the case of *love*, we noted how the Sinhala text of The Alchemist used a combination of the low variety and high variety forms of the word, giving the emotive contexts of the text a more refined sense of the word *love*.

Therefore, we propose that the impact of diglossia may provide Sinhala speakers a broader understanding of the meaning of a given emotion concept, based on whether the label used is of high variety or low variety.

#### 4.4.2 Presence of Religious Terminology

As we discussed in section 2.4, Buddhist religious concepts have a strong influence on the Sinhala language.

Interestingly, the Sinhala SRs for all three emotion terms contained synonyms with Buddhist religious connotations. This was not noted in any of the English SRs. As a result, we note that Sinhala speakers may associate these emotion terms more strongly with religious meanings, while English speakers might be less likely to do so. The association of emotion terms with religion may give Sinhala speakers a more devout or spiritual sense of meaning. In section 2.1, we established that the way an emotion is perceived is likely to be a result of the psychology of emotions, the features of a language, and sociocultural factors that influence language communities. In the case of Sinhala and the presence of religious terminology, we infer that Sinhala speakers are likely to be more impacted by the third factor above than English speakers.

#### 4.4.3 Availability of Larger Emotion Vocabulary

In each of the SRs, we noted that Sinhala has a much larger set of synonyms for a given emotion term, compared to English. This may imply that the emotion vocabulary of Sinhala is larger, compared to English. The availability of a larger emotion vocabulary can indicate that Sinhala speakers might have more facets of meaning for each emotion term.

Now that we have discussed the way in which we created and derived insights from the SRs, we proceed to how we can extend this work into the OESEL ontology.

## 5. Conceptual Framework and the Architecture of the Ontology of English and Sinhala Emotion Lexicon

In this section, we discuss the architecture of OESEL, along with details of implementation and some useful ways of querying the ontology.

In the creation of the SRs, we used an entirely text-based approach to categorising the emotion labels. However, a limitation of this approach is that it makes the semantic fields used in the SRs subjective. To resolve this limitation, we use the psychological models of emotion dis-

cussed in section 2.2 as the basis for developing the semantic fields. Upon evaluating the different psychological models and theories, we use the wheel of emotions model by Plutchik (1970) to derive the primary semantic fields for 8 different emotions. Then, the emotion labels are further categorised using additional metrics for a more refined analysis of emotion terms. Based on Russell's model, valence and arousal are used to place emotion labels on a continuum. Intensity is used as a metric to provide a weight aspect to each emotion label. Context and trigger are used to provide additional background information regarding the terms.

This approach gives us a mechanism to place an emotion label on a well-scoped web of emotion concepts, thereby enabling an organised method of emotion lexicon retrieval. Colour semantics is a good analogy to understand our approach (Golda et al., 2022; Jonauskaite et al., 2020). For ease of comprehension, we draw comparisons between our method for emotion analysis and the red-green-blue values (RGB values) used in the identification of colours. When colours are mapped using a unique identifier based on its component primary colours, it is much easier and objective to retrieve and communicate the semantics of colour. For instance, the colours *mauve*, *lilac*, and *lavender* are all English labels for different shades of purple. However, in Sinhala, there is only one label, ලා දම් (*Laa dham*, meaning light purple) for all of these shades of purple. As a result, it may be challenging to differentiate between *mauve*, *lilac*, and *lavender* in Sinhala, if only the words are being used. However, if one were to give a language-agnostic, RGB value-based label for each of these shades, then it removes the need for the meaning to be conveyed solely by the language label. For instance, *lilac* is R: 200, G: 162, B: 200, whereas *mauve* is R: 224, G: 176, B: 255. With this approach, conveying the meaning of colour, as well as the retrieval of it using RGB values, is much more objective. As a result, identifying a specific shade of purple in a Sinhala-English cross-linguistic setting is more meaningful and reliable when using the RGB values of the colours. The ontological approach we propose to disintegrate emotions into component elements heavily overlaps with the RGB-based approach of colour semantics.

Elaborating further on the design choices, since this study is primarily an explorative work to test the feasibility of extending the findings of initial SRs to an ontological framework, we made the decision to populate OESEL only with unique terms captured in the SRs, based on WordNet and Madura Online. Our aim is to ensure that the core assumptions and primary use cases of OESEL hold with a set of sample text data, thereby laying the foundational groundwork to create a fully-fledged and feature-rich ontology of emotion lexicon, which we see as the future direction for our work (see section 6 for further details).

### *5.1 Competency Questions*

As noted earlier, the primary purpose of this work is to develop a conceptual framework to map similar emotion terms across Sinhala and English, so that emotion labels can be identified at a more granular level. We start the development of the ontological framework by identifying the competency questions that we want the ontology to answer.

A set of competency questions to demarcate the scope of OESEL is given below. This is not an exhaustive list, but a representative one, where the questions are meant to provide a starting point to guide the development of the ontology. The list does not limit the scope of the framework, and we may expand its scope if other suitable questions appear.

(1) What are all the Sinhala terms that map to the English emotion concept *love*?

(2) What are all the English and Sinhala terms under the Plutchik category *acceptance*?

(3) What are the different Sinhala terms for the emotion concept *desire*, and what are their levels of valence, intensity, and arousal?

(4) What are the informal terms used for the term *love* in Sinhala?

(5) Do the English and Sinhala languages have labels for an emotion that is in the primary Plutchik category *rage*, and has moderate intensity and moderate arousal?

Section 5.3 provides examples of three SPARQL Protocol and RDF Query Language (SPARQL) queries that we use to test information retrieval from the ontology. These SPARQL queries can be considered a practical implementation and a feasibility check of some of the above competency questions.

### *5.2 Architecture of the Ontology*

This section presents the architecture of the ontology, including component elements such as classes, properties, and axioms. See Fig. 2 for a visual representation of the architecture of OESEL. The ontology is developed and maintained in Protégé (Musen, 2015; Stanford Division of Computational Medicine, Stanford University, Stanford, CA, USA). An OWL file containing the latest version of OESEL is available at https://github.com/malithia/oesel for reference.

The design and architecture of OESEL, including the way emotion concepts and terms are captured and represented, draws from lemon, Lexicon Model for Ontologies. The lemon model is proposed as a representation "to allow lexical information to be represented relative to an ontology" (McCrae et al., 2011). We make comparisons between OESEL and lemon to situate our work in a more mature ontology of lexicon. Aligning with lemon further helps us validate our design choices and approach, and ensures our work remains relevant and connected to established work. Fig. 3 shows some of the key components of the lemon model.

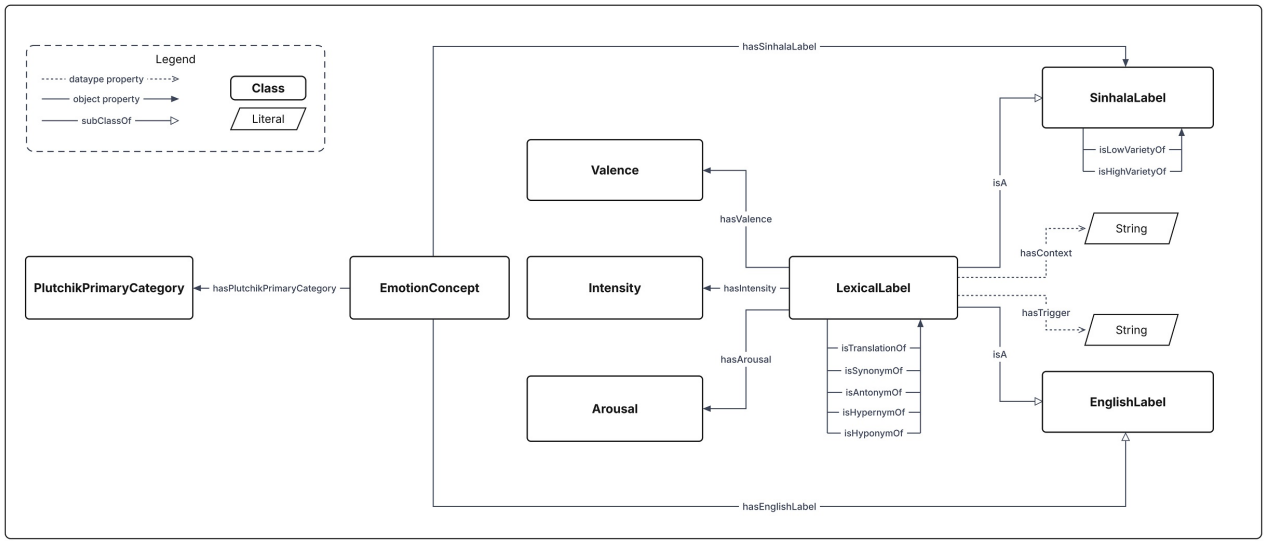


**Fig. 2. The architecture of the proposed ontology of English and Sinhala emotion lexicon**. This is a visual representation of how the ontology brings together the relationships between linguistic and psychological concepts related to emotions. The legend at the top left of Fig. 2 explains the meaning of the different components used.

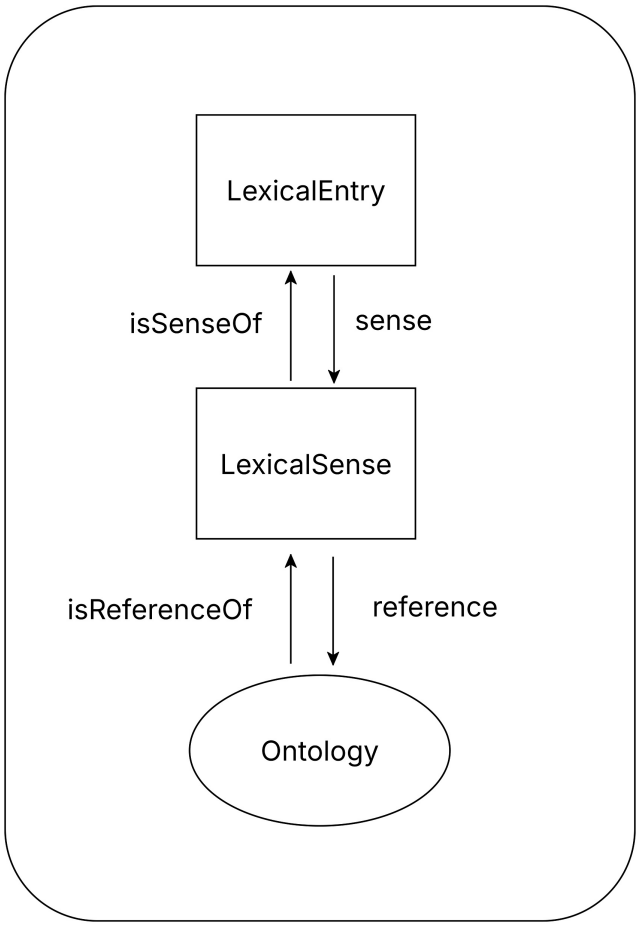


**Fig. 3. Some key components of the lemon model (**McCrae et al., 2012**)**. This figure shows some key components of lemon, including LexicalEntry, LexicalSense, and reference. This diagram is a simplified adaptation of the lemon core, available at: https://lemon-model.net/lemon-cookbook/node3.html.

As shown in Fig. 3, in lemon, LexicalEntry and LexicalSense are separate classes, where LexicalEntry represents a term from the selected lexicon and LexicalSense represents the relationship between the lexical entry and the ontology entity. The reference relation points to the resource that can be described by a given LexicalEntry. The assumption in lemon is that "each lexical entry is not semantically disambiguated", and as such, LexicalSense is used to map a specific word occurrence to a specific meaning (McCrae et al., 2012). In the architecture of OESEL, we use similar reasoning to that of lemon, and use LexicalLabel and EmotionConcept to differentiate between the concept of an emotion and a word for an emotion. Valence, intensity, and arousal attach a specific sense of the emotion to the LexicalLabel to capture word-level granularity, which cannot be captured by the concept of an emotion alone.

Details of the core classes, properties, and axioms of OESEL are further discussed below.

#### 5.2.1 Understanding the Core Classes

The classes in Fig. 2 take two broad categories. These are: The classes that provide psychological context and the classes that provide linguistic context.

EmotionConcept class functions as the core class that bridges the psychological and lexical elements of emotions. Each EmotionConcept has a PlutchikPrimaryCategory, derived using Plutchik's model of emotions (Plutchik, 1970). In the conical representation of emotions, Plutchik notes how across each cross-section of the cone, there is a set of emotions that are of a specific intensity. Keeping inline with this, we model the eight emotions at the top of the inverted cone as instances of the PlutchikPrimaryCategory class. By situating each emotion concept within one of Plutchik's categories, we aim to place each emotion term within a well-defined space of emotions.

LexicalLabel is the language label used to identify an emotion concept. This demarcation allows us to treat emotion words as labels that point to emotion concepts. The classes Valence, Arousal, and Intensity are used to show the degree of change between different emotion terms that point to the same emotion concept. This feature of the OESEL is what makes it possible to map labels of different languages to the same emotion concept and thereby map emotion lexicons across languages. SinhalaLabel and EnglishLabel are identified as subclasses of LexicalLabel to show the relationships labels have with each other and with the larger emotion concept. Words that are used to identify an emotion concept in Sinhala or English are modelled as instances of SinhalaLabel or EnglishLabel, respectively.

For example, in the instance of *love*, the EmotionConcept, *love* functions as the base entity. Under the psychological aspects of the emotion, we identify its PlutchikPrimaryCategory as acceptanceCategory. Under linguistic elements, English and Sinhala terms such as *love*, ආදරය (*Aadaraya*), ප්‍රේමය (*Premaya*), are then mapped using the SinhalaLabel and EnglishLabel. For each of these labels, we give features such as Intensity, Arousal, Context, and Trigger. Intensity, Valence, and Arousal are enumerated types with fixed sets of predefined categories as shown in Table 6.

**Table 6. Predefined categories of selected classes**.

| Class | Predefined categories |
|---|---|
| Intensity | Low, Mild, Moderate, High |
| Valence | Positive, Neutral, Negative |
| Arousal | Low, Moderate, High |

As the classes in Table 6 can only take one of the given values, we implement these classes as enumerated classes in our ontology. Setting up these classes as enumerated classes enables us to select from a defined set of instances per class, which lowers error. It also provides the opportunity to set up additional reasoning (DeBellis, 2019).

Context and Trigger contain free text input. Context encompasses contextual information such as religious terminology or informal or formal speech, which particularly ties to the findings made using SRs in section 4.4. Trigger refers to individuals, events, or experiences that can lead to a certain emotion. For instance, we can say that *anger* has the trigger "stressful situation", or *fear* has the trigger "traumatic event". The trigger for an emotion term can significantly vary based on the language context, hence why Context and Trigger are particularly used with LexicalLabel. For instance, as discussed in the insights from the SRs in section 4.4, Sinhala emotion vocabulary shows persistent Buddhist religious connotations. As a result, for a Sinhala speaker, a religious experience may be a trigger to an emotion identified by a specific emotion term, whereas a similar phenomenon may not be present for an English speaker for the same emotion concept. Being able to encode context at word-level enables greater semantic preservation in OESEL, as each term carries its nuances with it, while being situated in a defined emotion category.

#### 5.2.2 Understanding the Core Properties

Object properties such as hasArousal, hasValence, and hasPlutchikPrimaryCategory tie the LexicalLabel to its component features. hasTrigger and hasContext are data type properties, as we want to have more flexibility to incorporate a broader range of information for Trigger and Context.

As we input lexical information, we use a range of language-related features, such as isTranslationOf, isSynonymOf, and isHyponymOf to draw connections within individual entries. With more individual instances, these properties will create an intricate web of rich lexical data.

Drawing from the observations related to diglossia made using SRs in section 4.4, isLowVarietyOf and isHighVarietyOf are used as object properties of SinhalaLabel to capture the diglossic nature of Sinhala.

For example, the term ආදරේ (*Aadare*) is a low variety form of *love* or ආදරය (*Aadaraya*) that is used in informal conversations. OESEL captures the lexical information around the emotion concept *love* as follows:

loveConcept — hasEnglishLabel → loveLabel
loveConcept — hasSinhalaLabel → aadarayaLabel
aadareLabel — isLowVarietyOf → aadarayaLabel
aadareLabel — hasContext → informal

#### 5.2.3 Understanding Core Axioms

The lexical data in OESEL is bound by linguistic features, and the ontology uses axioms to demonstrate such features.

For example, in the case of synonyms, the following statement holds true: *If A is a synonym of B, then B is a synonym of A*. This is also true for concepts such as antonyms or translations. Consider these examples: *If inclusion is an antonym of exclusion, then exclusion is an antonym of inclusion*. Or, *if love is a translation of* ආදරය *(Aadaraya), then* ආදරය *(Aadaraya) is a translation of love*. As a result, in OESEL, object properties such as isTranslationOf, isSynonymOf, and isAntonymOf are symmetric object properties. The World Wide Web Consortium (W3C) defines that "an object property symmetry axiom SymmetricObjectProperty (OPE) states that the object property expression OPE is symmetric—that is, if an individual x is connected by OPE to an individual y, then y is also connected by OPE to x" (World Wide Web Consortium, 2012).

OESEL further uses the inverse object property axiom to show additional semantic relationships. In the ontology, two pairs of inverse properties, (isHypernymOf, isHyponymOf) and (isHighVarietyOf, isLowVarietyOf) are used. With high variety and low variety terms in Sinhala, the following statement holds true: *If* ආදරය *(Aadaraya), is a high variety term of* ආදරේ *(Aadare), then* ආදරේ *(Aadare) is a low variety term of* ආදරය *(Aadaraya)*. For English, we can say, *if love is a hyponym of affection, then affection is a hypernym of love*. More generally, W3C states that "an inverse object properties axiom InverseObjectProperties (OPE1 OPE2) states that the object property expression OPE1 is an inverse of the object property expression OPE2. Thus, if an individual x is connected by OPE1 to an individual y, then y is also connected by OPE2 to x, and *vice versa*" (World Wide Web Consortium, 2012).

In examining the linguistic elements of OESEL, we draw parallels once again with lemon to situate our work within a more established framework. In lemon, five modules, linguistic description, variation, phrase structure, syntax and mapping, and morphology are used to provide additional details for more sophisticated lexicon (McCrae et al., 2012). In its current version, OESEL does not include functionality as complex as lemon to work with the linguistic elements of a lexicon. However, the axioms in OESEL closely follow the variation module of lemon to provide additional information regarding the relationship between different LexicalLabel instances. Fig. 4 shows how the term variation module captures sense relations in the lemon model. Semantic relationships such as hypernymy, hyponymy, and translation are captured in both OESEL and lemon.

OESEL employs eight basic emotion categories, along with associated lexical labels, to represent emotion terms in different languages corresponding to each emotion category. As a result, linguistic features such as hypernym, hyponym, and antonym show the words' relation to each other. These linguistic representations can be used to understand how emotion concepts may relate to each other in a given language. An alternative to this representation is to extend the EmotionConcept class to directly model the relationship between emotion concepts. However, given the focus of OESEL on emotion lexicon rather than on emotion concepts, we use linguistic features to show the semantic variation of emotion labels and to demonstrate how the meaning fields of labels relate to each other.

### *5.3 Examples for Practical Usage*

This section demonstrates the practical applications of OESEL using three examples.

#### 5.3.1 Example 1: Context-Aware Translation

During the early analysis of texts and SRs, a key observation made was that Sinhala has high variety and low variety terms, used in different contexts, which is not a feature of the English language. As a result, in translations, emotion words can get grouped together in a manner that reduces the semantic variability of the term. However, there is opportunity to infer more contextual information and make more nuanced word choices during translation. OESEL bridges gaps that may exist in semantic inference by providing a rich web of emotion word data that are mapped using psychological concepts.

Consider the following query in OESEL and its output to retrieve Sinhala labels for a given emotion concept with context data.

Description of query: Retrieve the Sinhala labels that point to the emotion concept *happy*, along with related contexts. Present the terms in alphabetical order of the Sinhala label name.

SPARQL query:

```
PREFIX oesel: <http://example.org/oesel-ontology#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?sinhalaLabel ?context
WHERE {
oesel:happyConcept a oesel:EmotionConcept;
oesel:hasSinhalaLabel ?sLabel.
?sLabel a oesel:SinhalaLabel;
```

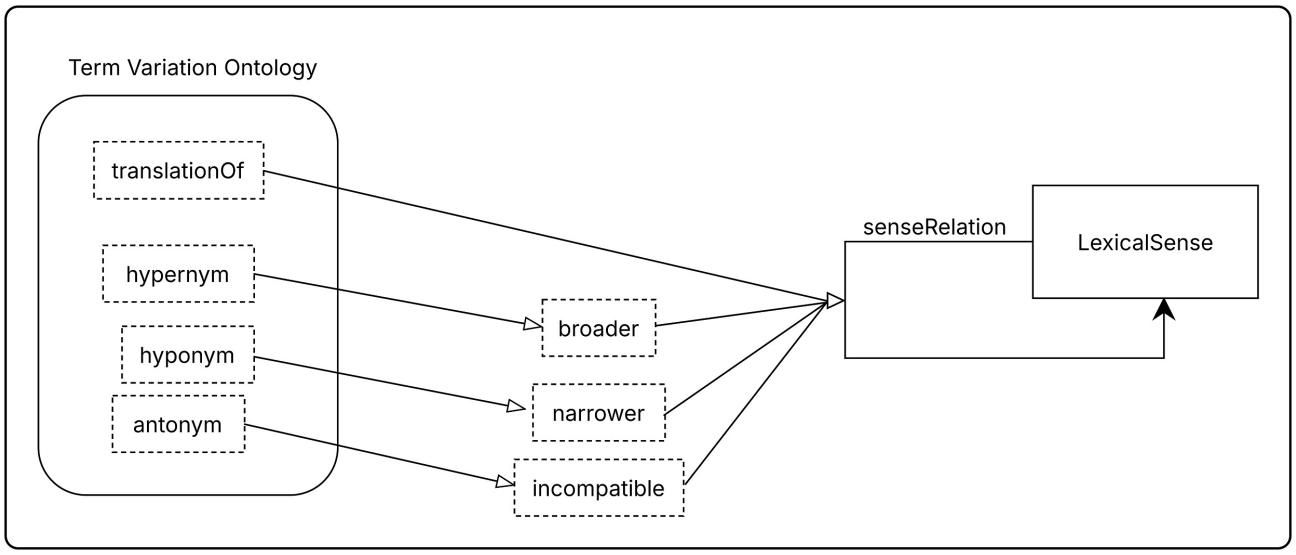


**Fig. 4. Modelling lexicosemantic relationships in lemon (**McCrae et al., 2012**).** The lemon model uses the variation module to map semantic relationships between references. This figure is a simplified adaptation of a part of the variation module. For the complete figure, please see: https://lemon-model.net/lemon-cookbook/node13.html.

rdfs:label ?sinhalaLabel;
oesel:hasContext ?context.
}
ORDER BY ?sinhalaLabel

Protégé output:

Fig. 5 gives the Protégé output for this SPARQL query of OESEL.

We see that for a given emotion concept, we can retrieve the Sinhala labels with additional information on contexts. This enables translators to make more context-aware lexical choices in translation.

#### 5.3.2 Example 2: Retrieving Emotion Vocabulary Based on the Psychological Concept

In this example, we want to retrieve emotions via the underlying emotion concept, based on Plutchik's psychological model of emotions, rather than arbitrary emotion concepts.

Consider the following query in OESEL and its output to retrieve emotion concepts by the primary Plutchik category.

Description of query: Retrieve all Plutchik categories, along with all English and Sinhala labels under the category.

SPARQL query:

PREFIX oesel: <http://example.org/oesel-ontology#>

PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>

SELECT ?plutchikCategory
(GROUP_CONCAT(DISTINCT ?engLabelText; separator=", ") AS ?englishLabels)
(GROUP_CONCAT(DISTINCT ?sinLabelText; separator=", ") AS ?sinhalaLabels)
WHERE {
?concept a oesel:EmotionConcept.
?concept oesel:hasPlutchikPrimaryCategory ?plutchikCategory.
OPTIONAL {
?concept oesel:hasEnglishLabel ?engLabel.
?engLabel rdfs:label ?engLabelText.
}
OPTIONAL {
?concept oesel:hasSinhalaLabel ?sinLabel.
?sinLabel rdfs:label ?sinLabelText.
}
}
GROUP BY ?plutchikCategory
ORDER BY ?plutchikCategory

Protégé output:

Fig. 6 gives the English and Sinhala labels retrieved from OESEL via Protégé for this SPARQL query. The first row shows the labels under the acceptance category, and the second row shows the labels under the vigilance category. The column containing details of the Plutchik category has not been included in Fig. 6 to improve visibility.

In the output, we see that all emotion labels associated with a given Plutchik category are retrieved, regardless of the specific emotion concept with which they are conventionally associated. However, also note that at the moment, there are only two Plutchik categories in the ontology, as we only populated it with sample data from the initial SRs.

#### 5.3.3 Example 3: Understanding the Emotion Semantic Space Within Each Language

A common observation in emotion lexicon across languages is that there are emotion terms unique to a language.

| sinhalaLabel | context |
|---|---|
| "kulmath"@si | "formal" |
| "muditha"@si | "religious, formal" |
| "preethimath"@si | "formal" |
| "sukhitha"@si | "formal" |
| "thushta"@si | "formal" |
| "thusnaa"@si | "formal" |
| "thutu"@si | "formal" |
| "yogya"@si | "formal" |

**Fig. 5. Protégé output for example 1**. The results of the SPARQL query in example 1, as given in Protégé.

| englishLabels | sinhalaLabels |
|---|---|
| "enjoy, affection, love, regard, sexual_desire, in_love" | "aadaraya, dayaawa, alma, premaya, nuraa, senehasa, saadaraya, pema, aadare" |
| "want, hope" | "kamaththa, rusi, risi, abhiruchiya, abhilaashaya, thrushnaawa, thanhaawa, aasaawa" |

**Fig. 6. A snippet of the Protégé output for example 2**. The English and Sinhala labels retrieved using the SPARQL query in example 2, as given in Protégé.

When words refer to tangible items or concepts, identifying and filling any lexical gaps is easy. For example, words such as *computer* or *recycling*, which originated in English, had no pre-existing equivalents in Sinhala. However, such gaps can be identified and filled, as the concept is easy to identify.

Locating missing terms and creating labels are rather challenging in abstract concepts. For instance, the Merriam-Webster dictionary defines *nostalgia* as a wistful or excessively sentimental yearning for return to or of some past period or irrecoverable condition. At the point of writing this paper, Google Translate does not have a Sinhala entry for nostalgia, and the Madura Dictionary gives two terms which are close approximations, කාන්සාව (*Kaansaawa*) and සාංකාව (*Saankaawa*). Both these terms are closer in meaning to loneliness than nostalgia.

Using OESEL, we are able to retrieve emotion concepts based on psychological features such as intensity, valence, and arousal, and then evaluate the vocabulary available for each language under each specific psychological thread.

For instance, consider the following SPARQL query and its output to retrieve all Sinhala labels under different emotion concepts, along with their intensity, arousal, and valence.

Description of query: Retrieve all emotion labels, subcategorised by emotion concept. Then give all the Sinhala labels for the emotion concept with accompanying categorisations for intensity, valence, and arousal.

SPARQL query:

PREFIX oesel: <http://example.org/oesel-ontology#>

PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>

SELECT ?concept ?sinhalaLabel ?valence ?intensity ?arousal

WHERE {

?concept oesel:hasSinhalaLabel ?label.

?label rdfs:label ?sinhalaLabel.

OPTIONAL { ?label oesel:hasValence ?valence. }

OPTIONAL { ?label oesel:hasIntensity ?intensity. }

OPTIONAL { ?label oesel:hasArousal ?arousal. }

}

ORDER BY ?concept ?sinhalaLabel

Protégé output:

Fig. 7 gives the Protégé output for this SPARQL query of OESEL.

This example shows that by retrieving the emotion concept and accompanying categories, we can understand the various facets of meaning associated with the emotion

| concept | sinhalaLabel | valence | intensity | arousal |
|---|---|---|---|---|
| desireConcept | "aasaawa"@si | positive | mild | moderate |
| desireConcept | "abhilaashaya"@si | positive | moderate | moderate |
| desireConcept | "abhiruchiya"@si | positive | low | low |
| desireConcept | "kamaththa"@si | positive | mild | moderate |
| desireConcept | "risi"@si | positive | low | low |
| desireConcept | "rusi"@si | positive | mild | low |
| desireConcept | "thanhaawa"@si | negative | moderate | high |
| desireConcept | "thrushnaawa"@si | negative | high | high |
| happyConcept | "kulmath"@si | positive | moderate | moderate |
| happyConcept | "muditha"@si | positive | mild | low |
| happyConcept | "preethimath"@si | positive | high | high |
| happyConcept | "sapa"@si | positive | moderate | moderate |
| happyConcept | "sapawath"@si | positive | moderate | moderate |
| happyConcept | "sukhitha"@si | positive | mild | moderate |

**Fig. 7. Protégé output for example 3**. The results of the SPARQL query in example 3, as given in Protégé.

concept. For instance, under *desire* there are two Sinhala terms with negative valence, which is not an observation we noted with English terms (the English terms are not shown in the figure). This may prompt a user to further evaluate what these terms with negative valence are, why they have negative sentiment, and how they are used by speakers of Sinhala.

Extending this example further, we believe that OESEL may also be able to cope better with the challenge of bidirectional mapping. Previously, we noted how Sinhala has a greater number of emotion words for the selected key words, compared to those of English. For example, in the SR for *happy* in Fig. 1, the English word *joy* has three Sinhala words in the same semantic field, ප්‍රීතිමත් (*Preethimath*), කුල්මත් (*Kulmath*), and තුස්නා (*Thusnaa*). When translating from Sinhala to English, it is straightforward to select *joy* as the English word for any one of these Sinhala terms. However, in English to Sinhala translation, there is no straightforward mechanism to decide which one of ප්‍රීතිමත් (*Preethimath*), කුල්මත් (*Kulmath*), or තුස්නා (*Thusnaa*) is the best-suited word for *joy*. In such an instance, we can utilise any available contextual information for the word occurrence *joy* and make an attempt to map it to the valence, intensity, arousal, context, and trigger of the available synonyms for Sinhala, thereby deciding on the most suitable Sinhala term. For example, in the instantiation of this ontology, we have given the Sinhala words ප්‍රීතිමත් (*Preethimath*) a categorisation of high intensity and high arousal, and කුල්මත් (*Kulmath*) a categorisation of moderate intensity and moderate arousal, thereby indicating that ප්‍රීතිමත් (*Preethimath*) may be more suitable to indicate a stronger sense of joy. Based on the way the term *joy* occurs in the English context, the user can then select between these terms. However, this is still not a complete solution to the challenge of bidirectional mapping, and we have included further discussion regarding this under section 6.1 of this paper.

Now that we have looked at the architecture and implementation details of OESEL, along with some practical ways of using the ontology, we proceed to conclusions, limitations, and further applications of our work.

## 6. Conclusions, Limitations, and Further Applications

In this section, we provide the conclusions and limitations of our study, along with directions identified for further inquiry.

At the beginning of this work, we set out to answer two research questions:

(1) How can cross-linguistic emotion semantics between English and Sinhala be represented formally in an ontology?

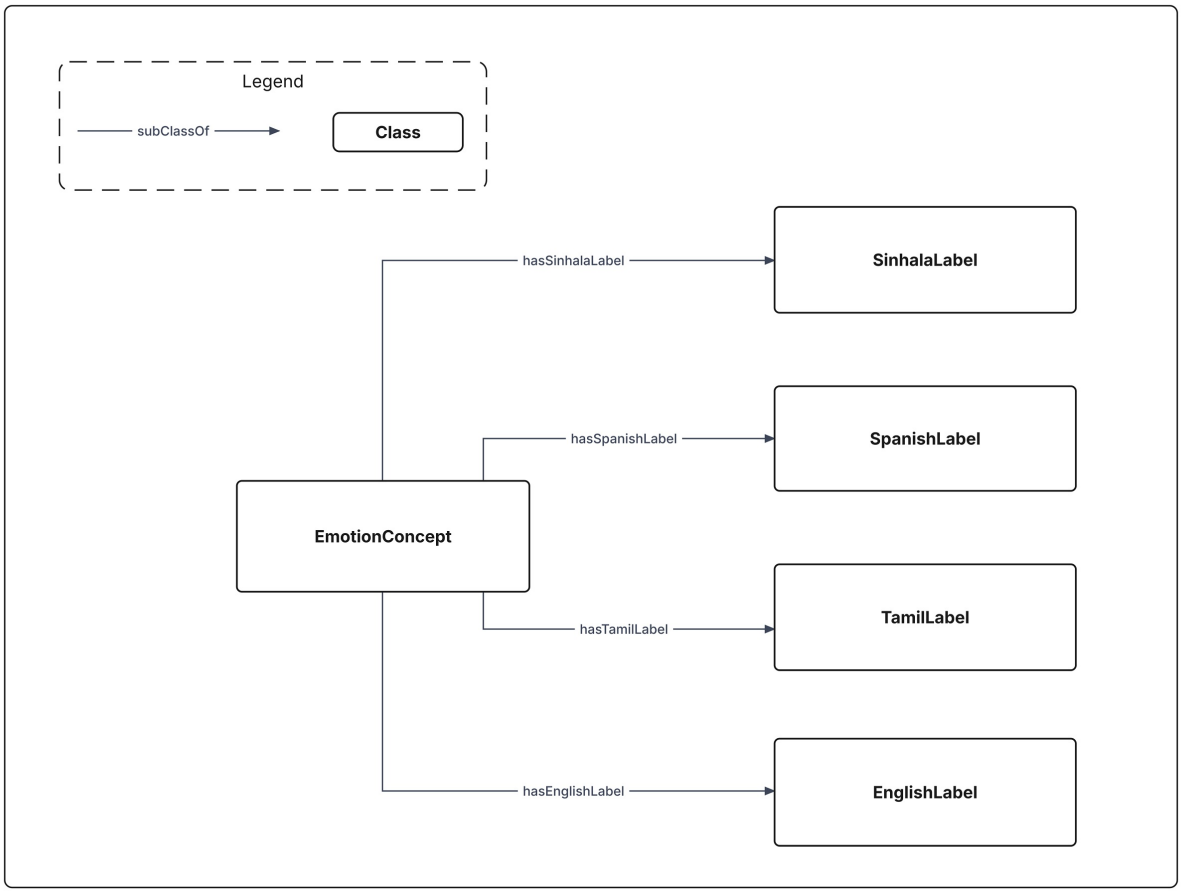


**Fig. 8. Architecture to extend the ontology to other languages**. This is a simplified version of Fig. 2, showing how the EmotionConcept class can be modified to add further languages to the ontology.

(2) To what extent can such an ontology capture the cultural and linguistic nuances of a low-resource language such as Sinhala, and support the retrieval of emotion terms and their contextual properties?

Upon developing the architecture of OESEL and implementing and querying the ontology, we conclude that drawing from the theories and models of psychology, linguistics, and information science, our proposed ontological approach to modelling emotion lexicon can provide a meaningful mechanism to map and retrieve emotion words with greater precision.

As we noted in section 1, an ontology of emotion lexicon can function as the semantic backbone of translation technology. OESEL has the ability to function as a model of the world, providing additional context regarding emotion lexicon to language tools. Especially for languages like Sinhala that lack large amounts of digitised text data, a more intentionally developed framework such as the OESEL could provide rich contextual data for more precise outputs in language technology.

### *6.1 Limitations and Challenges Identified*

In this section, we discuss three limitations and challenges we see in our design and implementation of the ontology.

(1) In conceptualising the architecture of OESEL (see section 5), we noted that the aim of this study is to establish the conceptual groundwork and the feasibility of a cross-linguistic ontology of emotion lexicon. As a result, we continued to work with the text data used for the SRs, thereby focusing on a pre-defined scope and a small sample of individuals in the ontology. This makes the ontology rather sparse. Further, we have used WordNet and Madura Online as underlying lexical resources to populate the ontology. Both these resources have their own limitations. For instance, WordNet includes polysemous entries, definitional phrases, and near-synonyms alongside strict synonyms. Due to these constraints in the instances used to populate the ontology, the actual examples may be flawed. However, we believe that this explorative inquiry has provided a rather reassuring foundational framework, and we aim to further enrich OESEL based on the current findings. Some key considerations at this point are:

(a) Extending text data beyond the keywords obtained from SRs: In our selection of emotion terms, we have only used three individual words as key words, along with their synonyms (which also contained phrases). Initially, we want to extend these terms to other emotion key words. However, emotive contexts move beyond individual and conspicuous emotion terms. For instance, emotion-related words such as "tears" or emotion-laden words, such as "death" may carry emotional connotations, based on interlocutors (Pavlenko, 2008). Even words and phrases with no obvious emotion contexts may acquire emotive connotations based on how and where the words and phrases are used (Ferré et al., 2025; Hinojosa et al., 2020). In order to account for such occurrences, we may extend the text data beyond what is considered emotion terms.

(b) standardising key words.

(c) expanding classes, properties, and axioms if necessary to cater to a robust set of competency questions.

(d) Bringing together a varied set of lexical resources in both English and Sinhala to populate the ontology, to reduce the reliance on WordNet and Madura Online.

(2) We extended Example 3 of section 5.3 to note that OESEL has some capability to navigate the challenges of bidirectional mapping using contextual information encoded for each lexical entry. However, this is not a complete solution to the problem of bidirectional mapping. For instance, two words may have the same intensity, valence, and arousal categories, making it impossible to differentiate words solely based on those factors. Moreover, subcategories under concepts such as valence are still rather broad and they alone may not provide sufficient details to differentiate between various terms. It is also possible that a user may not have additional contextual information on a specific occurrence of a word. As a result, OESEL does not have a complete solution to the problem of bidirectional mapping, and it is a line of inquiry we wish to explore further.

(3) Due to the limited nature of the current version of OESEL, the outputs received via Protégé are skeletal in nature. These outputs establish the feasibility of the retrieval mechanism in discussion, but they do not provide elaborate output for detailed exploration. However, as we progress with future work on OESEL, we believe we will be able to derive rich outputs from querying OESEL.

### *6.2 Further Applications*

There are a few further applications that we foresee for OESEL. We noted that an ontology of emotion lexicon can be the semantic backbone of translation tools. This can apply for emerging technology such as Large Language Models (LLMs). Especially with LLMs whose outputs are probabilistic, an ontology of emotion lexicon can ground the LLM in more realistic and practical language usage. For instance, Wu and Tsioutsiouliklis (2024) integrate knowledge graph structures and semantics into LLMs to show that knowledge graphs can increase the performance of LLMs. Other emerging work explores various ways in which ontologies and knowledge graphs can help ground LLMs (Agrawal et al., 2024; Ibrahim et al., 2024; Shang et al., 2024). We believe a similar application could derive significant value from OESEL.

In our sample SPARQL queries, we note that mapping emotion lexicon based on underlying psychological components may reveal lexical gaps in emotion vocabulary in different languages. We believe that we can use the Semantic Web Rule Language (SWRL) with OESEL to derive hitherto unknown or unrecognised relationships within emotion lexicon across languages. For an easy comparison, consider this example regarding human relationships: "…if John has Mary as a parent and Mary has Bill as a brother then John has Bill as an uncle" (Horrocks et al., 2004). OESEL enables us to uncover similar relationships with the use of SWRL rules and potentially explore ways of bridging lexical gaps within languages.

Further, given the architectural design of OESEL, it does not have to be limited to English and Sinhala. While holding the EmotionConcept class constant, the sub classes within LexicalLabel can be extended to as many languages as required. See Fig. 8 for an example of an extended ontology architecture. An extension of this nature will make the ontology a useful application across languages and linguistic communities.

## Availability of Data and Materials

The OWL file that supports the findings of this study is openly available in the following GitHub repository: https://github.com/malithia/oesel.

## Author Contributions

All authors contributed to the design of the research study. MA conducted the text and discourse analysis, and conceptualised and developed the synonym rings and the ontology. AV provided direction and advice on the research design, and contributed to conceptualising and developing the different research methods used. AB provided direction and advice on the overall research study conceptualisation and the development of the ontology. All authors contributed to the writing and editorial review of the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

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The authors declare no conflicts of interest.

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The authors acknowledge the use of generative AI tools for research and editorial support, in the form of searching for literature, summarising literature, copyediting, and refining SPARQL queries. AI tools were also used to improve the formatting, quality, and resolution of images, without altering, adding, removing, or reconstructing any information provided in the figures. The research output and the manuscript are the sole work of the named authors.

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