Towards the construction of a dataset of art-related synaesthetic metaphors: methods and results

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Abstract

This paper describes a model of synaesthetic metaphor in non-poetic and art-related texts, whose ultimate goal is to suggest sensory alternatives for contents accessed mainly by sight in museums and art galleries. We created and applied a multi-level annotation scheme to create a manually annotated resource of synaesthetic metaphors extracted from museum catalogues and designed a pipeline for the automatic detection and interpretation of synaesthetic metaphors in texts. Finally, we tested a preliminary implementation of this pipeline on real data, shedding light on the relevance and complexity of this phenomenon and the possible improvement areas.

Keywords

Synaesthetic metaphors, multi-sensory design, NL resources

1. Introduction

Synaesthetic metaphors (e.g., *velvet voice*,*warm colour*, *sweet fragrance*) can mimic synaesthetic perception stressing the multi-modal dimension of perception in language [1]. These consist of two subjects, *tenor* and *vehicle*, so the first (the tenor) can be economically described by a transfer of the implicit and explicit attributes of the second (the vehicle) [2].
In this paper, we introduce that synaesthetic metaphors mined from artworks descriptions might enable sensory access to objects' properties/qualities (artwork's properties/qualities), leveraging the information involved in the transfer as a systematic source of alternative perceptual information. The ultimate purpose of this study is to gather domain-specific synesthetic metaphors as samples for investigating neural activation over metaphor processing.
In order to collect ground truth data, we created an annotated corpus of 60 synesthetic metaphors gathered from museum catalogues (Tab.1). As part of this research, we also describe an annotation pipeline prototype based on syntactic and lexico-semantic knowledge sources, that we tested on real data. The results obtained by implementing the pipeline, which combines different classification methods to annotate and discriminate the occurrences of synaesthetic metaphors, provide insight on the nature of the phenomenon and suggest future research directions.

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This paper is structured as follows. After surveying the related work in Section 2, we describe the methodology behind the manual annotation and design of the pipeline (Section 3). Section 4 illustrates the evaluation of the proposed pipeline. Discussion and Conclusion end the paper.

2. Related work

Synaesthesia in language Synesthetic metaphors consist of two subjects: the *tenor* and the *vehicle*, so the first can be economically described by a transfer of the implicit and explicit attributes of the second [1].
The terms corresponding to tenor and vehicle in Lakoff's theory are *target* and *source*, two structures (or *domains*) underlying cognitive processes detectable in language [3].
One of the first systematic studies concerning synaesthetic metaphors was related to the directionality of mapping. Ullmann (1957) argues that in synaesthetic metaphors concepts of the so-called "lower" senses often correspond to the source, while concepts of the "higher" senses regularly regarding the target domain [1].

Interpretation and detection tasks Su et al. [4] suggested a method for interpreting syneshetic metaphors simulating cross-modal similarity between different perceptual modalities. Their model can exhaustively consider the semantic knowledge of the features, perceptual modality and sentiment and incorporate the cross-modality relations.
Tekiroglu et al. [5] examined how sensory features affect the recognition of metaphors. They offer a method to automatically identify these correlations from a dependency-parsed corpus and make use of an existing vocabulary linking English terms to sensory modalities. The findings reveal that sensory features are essential for detecting metaphors.
Lievers [6] provided a technique for the semi-automatic extraction of synesthetic metaphors to use with general-purpose corpora. Most transfers are spotted according to the Ullmann's schema, but some cases *reverse transfers* were reported (e.g., terrible cold).
Our approach rely on a more complete, explicit model of synaesthetic metaphor and differs from previous approaches in the use of annotated resources (lexica and datasets). Moreover, the model is tailored to synaesthetic metaphors in art descriptions.

Table 1
The dataset of museum synaesthetic metaphors.

Museum	Number of artworks	Number of metaphors	Ratio
IMMA	13 (493)	15	32,66
GAM	12 (38)	25	1,52
Hong Kong	20 (140)	20	7,00
All	45 (671)	60	11,18

3. Methodology and Resources

In order to create resources and tools for analyzing synaesthetic metaphors in artwork descriptions, we combined manual annotation and automatic tools to design a pipeline for detecting and analysing synaesthetic metaphors. After identifying the relevant syntactic, lexical and semantic features of synaesthetic metaphor from the literature, we manually identified and analysed its occurrences in the description of artworks in a set of museum catalogues. Secondly, we designed a pipeline which relies on a combination of supervised and unsupervised classification methods to detect and analyse the occurrences of this specific metaphor type. The ultimate goal is two fold: on the one side, leveraging manual annotation to collect ground truth data; on the other side, testing tools for the detection and study of synesthetic metaphors.

3.1. Manual annotation

Annotation Scheme Based on the syntactic, lexical and semantic features emerged from the literature on synaesthetic metaphor, we created a multi-level annotation scheme.
One of the authors manually annotated a corpus of 633 artwork descriptions (in English) taken from the catalogues of the Turin Gallery of Modern Art (Galleria d'Arte Moderna, GAM), the Irish Museum of Modern Art (IMMA) of Dublin, and the Hong Kong National Museum, with the goal of collecting ground truth data on synaesthetic metaphors in our domain.
The text was annotated by using GATE, a general architecture for text engineering [7].
Each description consists of an average of 345 tokens.
The annotation scheme includes:

- sentence-level contextual information: whether the excerpt includes visual information (e.g., painted or sculpted figures' position in space, argumentative description about visual features such as shapes, colors, brightness), abstract information (e.g., feelings and concepts), other sensory details (e.g., materials, textures), and historical data (e.g., biographies, historical events)
- multi-word synaesthetic metaphors, annotated for:
  - scheme in Ullmann's hierarchy
  - syntactic pattern
  - word-level information:
    - source and target that can be experienced through the sensory modalities
    - source and target that are associated with concrete

Painting: The Wood Pigeon's Nest (1874)
Contextual annotation:
<Collins' style developed out of a fascination and connection with the Irish landscape. His practice would often involve detailed studies of twigs and moss><biographical information>. <Misty hues> <synaesthetic metaphor> dominate his palette, contributing to the atmospheric mood. <Although Collins was primarily a landscape artist it was the concept of the land that concerned him – his work rarely related to a particular place but captures the romantic notion of a poetic Ireland><biographical information>. 'The Wood Pigeon's Nest' perfectly encapsulates

this atmospheric style. The image of nest and egg is central <visual description><sensory cue:position> The vulnerability and fragility of the nest is evoked<abstract concept>, the subject hew out of an abstract background <visual description>.
Annotation of synesthetic metaphors:
misty<haptic><hues><visual>

The annotated dataset As it can be seen in Table 1, there are significant differences in the synaesthetic metaphors found in the various museums. Some museums catalogues, in fact, seem to be more productive in terms of synaesthetic metaphors: for IMMA, in particular, only 13 synaesthetic metaphors were found for overall 493 artworks; on the other extreme, the GAM museum yielded 20 metaphors for only 38 artworks. Despite these huge differences, which may be motivated by cultural and linguistic differences in the tradition art writing and deserve further investigation, the role of synaesthetic metaphor proves to be relevant in artwork description.
From the GAM's catalog, 24 synaesthetic metaphors were identified for 12 different artworks. Most identified pairs belong to the adjective-name pattern, while rarely to the verb-noun pattern. For the IMMA (Irish Museum of Modern Art) catalog, 14 synaesthetic metaphors were identified for 13 different artworks. As well for the GAM's catalog, most pairs belong to the adjective-name pattern, while infrequently to the verb-noun pattern.
From the point of view of detection and interpretation, then, it is also worth considering the frequency of the various schemes. In the IMMA and GAM's catalogues, we have identified 40 synaesthetic metaphors: over 80% reflect the mapping between touch and vision (e.g., *cold picture*,*warm colour*, *sensuous tone*). In parallel, all metaphors identified in the IMMA catalogue represent the same directionality. For the analyzed catalogues, synaesthetic metaphors rarely involve the gustatory, olfactory and hearing modalities. For the GAM catalogue, a few samples of this type were identified, with a frequency of less than 12% (e.g., *erotic flavour*, *fresh tone*); the synaesthetic metaphors collected from the IMMA's catalogue also feature a shallow range of modalities, excluding the gustatory and olfactory ones. Nevertheless, for this catalogue, a rarefied tactile dimension emerges without reference to taste or smell. The preference for visual, haptic mapping is confirmed for the Hong Kong museum. Compared to the IMMA and GAM catalogues, 25% of the collected metaphors from the Hong Kong Museum are descriptive of the brushstrokes on the canvas, e.g. described as delicate, crisp, and rigorous.
Notice that this ordering confirms the findings are also in line with the hierarchy of modalities, according to which synaesthetic metaphors proceed from the higher to lower modalities.

Collecting art-related descriptions In order to gather further text data for testing the manual and automatic annotation tools, we created a corpus of artwork descriptions (Corpus A) via web scraping from Google Arts and Culture. Launched in February 2011 by Google, it hosts around six million high-resolution images of works of art worldwide, sometimes complemented by a textual description and metadata such as title, author, and date. This corpus includes artworks descriptions from a set of ten different western and eastern countries (Table 2), selected on the basis of the diversity of collections, cultures and geographical area.

Table 2
The ten museums included in Corpus A

Museum	Geographic Area	Number of artworks
Kyoto National Museum	Japan	200
Hong Kong National Museum	China	140
Museo Nacional De Arte	Mexico	161
National Gallery	United Kingdom	226
Muzeul Național Brukenthal	Romania	74
Musée d'Orsay	France	277
Uffizi Gallery	Italy	156
National Museum New Delhi	India	770
The State Russian museum	Russia	144
Nationalmuseum Sweden	Sweden	99

3.2. Metaphor detection and interpretation pipeline: a proposal

The annotation pipeline we designed and tested on the annotated data encompasses three main steps.

1. **Syntactic annotation.** Artwork descriptions from the museum catalogues are parsed and the word pairs which match the syntactic patterns of synaesthetic metaphor are extracted, yielding a set of candidate synaesthetic metaphors.
2. **Identification of sensory modalities**. In this phase, the candidate word pairs are automatically annotated for the sensory modalities using a multi-classifier. This step relies on lexical resources for the identification of the sensory modalities of words.
3. **Filtering**. In this phase, the candidate word pairs, enriched with the sensory domains in the previous step, are matched against the synaesthetic metaphor schemes provided by Ullmann (Section 2). Only the pairs which realize one of the possible schemes are kept, while the others are discarded: for example, word pairs where source and target belong to the same sensory modality cannot qualify as synaesthetic metaphors.
4. **Classification**. In this phase, a binary classifier is run on the obtained word pairs to identify the actual synaesthetic metaphors.

In the following, we describe the experiments carried out to assess the feasibility of the pipeline.

Syntactic annotation In order to extract from art descriptions the syntactic patterns which characterize synaesthetic metaphor, we used a well-established, standard format and pipeline for syntactic annotation (Universal Dependencies, UD) [8]. This tool relies on the GUM treebank for English, developed on top of UD, which includes as genres academic, blog, fiction, government, news, nonfiction, social, spoken, web, and wiki [9]. We used the UDeasy suite [10] to parse the syntactically annotated linguistic data and extract the syntactic patterns from a CoNLL-U format.
After parsing, we extracted four dependency patterns, each composed of a word pair:

- adjective (*adj*) – noun (*nn*) where *nn* is parent of *adj* & *adj* precedes *nn* by exactly one position,

- adjective (*adj*) – noun (*nn*) where *nn* is parent of *adj* & *adj* precedes *nn* by exactly two positions,
- adjective (*adj*) – noun (*nn*) where *nn* is parent of *adj* & *adj* precedes *nn* by exactly three positions,
- verb (*vrb*) – noun (*nn*) where *nn* in parent of *vrb* & *vrb* precedes *nn* by exactly one position.

Identification of sensory modalities We applied a multi-class classification with logistic regression to map the words involved in synaesthetic metaphors onto seven classes [11] which represent the five sensory modalities and the abstractness/concreteness dimension.
In order to maximise model performance, we focused on the main three hyper-parameters : solver, penalty and regularization strength. We configured the LogisticRegression class for multinomial logistic regression by setting the 'multi_class' argument to 'multinomial' and the 'solver' argument to a solver that supports multinomial logistic regression, the 'lbfgs'.
We evaluated the classification model using a stratified 10-fold cross-validation. Stratification ensures that each fold of the cross-validation has approximately the same distribution of examples in each class of the entire training dataset. In this case, the multinomial logistic regression model with default penalty achieved an average classification accuracy of 69.9%.
We used two datasets: the first dataset (Dataset 1), issued from manual annotation, maps words to sensory modalities [12][13][14]; the other dataset maps words to the concreteness and abstractness dimensions based on individuals' neural activation [15]. Although abstractness and concreteness are irrelevant in the detection task, since words in synesthetic metaphors can have similar values for the two dimension [6], we used these to predict the perceptual strength of words that were unclassified in one of the sensory classes but could still be experienced through one of the five modalities. For example, the word *diamond* belongs to the concrete dimension, but can also be recognized as visual-related in more refined classification tasks.

- *Dataset 1* (which actually includes 3 dataset developed along time) was introduced by Lievers and Winters to investigate how sensory information is encoded across lexical categories [16]. It includes 1,123 words: 423 adjectives and 400 nouns from Lynott and Connell [12][13], and 300 verbs from Winter[14] [17].
- *Dataset 2* was introduced by Conca et al. [15] to measure neural response to abstract and concrete concepts. It includes 96 abstract and 96 concrete nouns categorized in main four classes: the abstracts to emotions, cognitions, attitudes, and human actions including 24 stimuli for each category, the concrete ones to biological entities and artifacts including 48 stimuli for each category.

A relevant issue is given by the fact that the datasets employed to map words to the five senses contain considerable noise. For example, in Lynott and Connell's dataset of nouns paired with sensory domains, many nouns are highly abstract, and only some are directly related to perception [13].

Filtering Since the model encompasses constraints on the cross-modal directionality, we applied the scheme provided by Ullmann (1957) for the directionality of the sensory mapping to the extracted word pairs

Table 3
Word pairs extracted from the Hong Kong museum catalogue

Node 1	Node 2	Distance	Pairs
Adjective	Noun	1	1112
Adjective	Noun	2	212
Adjective	Noun	3	92
Verb	Noun	1	16

Classification We run the Hugging-Face zero-shot classification pipeline to classify the resulting word pairs into metaphorical and non-metaphorical classes.
Yin et al.[18] proposed a method for using pre-trained NLI models as classifiers of zero-shot sequences. Thus, we used Facebook's bart-largemnli model [19], which is a checkpoint model further trained on the MNLI (Multi-Natural Language Inference) dataset, as basic model for the zero-shot classification model. The used candidate labels were "metaphorical" and "non-metaphorical".
The use of this pipeline, not been previously tested for synaesthetic metaphor, represents a first attempt to automatically identify the occurrences of this specific metaphor type. In addition, it can provide insight on the complex relationship between metaphor and synaesthetic metaphor. The Vrije Universiteit Amsterdam Amsterdam Metaphor Corpus is the largest available corpus hand-annotated for all metaphorical language use, regardless of lexical field or source domain. The VUA corpus was annotated to detect indirect, direct, and implicit metaphors, personification, metaphor signal and borderline cases. It does not include synthetic metaphors [20].

4. Pipeline evaluation

The pipeline has been tested on the dataset of the Hong Kong museum, which yielded the highest number of occurrences of synaesthetic metaphor in the manual annotation phase. In particular, starting from the results of the syntactic analysis (see Table 3), we focused on the steps which rely on less established tools, namely step 2 (Automatic annotation of sensory modalities) and 4 (Zero-shot classification). The output of these two steps has been compared with the manually annotated data to assess the performance of the automatic tools, and gain insight from discrepancies.

Automatic annotation of sensory modalities The multi-class classification was used to annotate the 133 word pairs, extracted from the catalogue of the museum, which belonged to Ullmann schemes (see Table 4). By doing so, we can evaluate the obtained classification, we considered not only the pairs corresponding to the actual metaphors found by the human annotator, but the overall set of pairs identified by filtering the candidate word issued from the syntactic analysis with the schemes identified by Ullmann. By doing, so we can assess the performance of the classifier within the context of the real pipeline. The accuracy of the multi-class sensory modality classification was measured by comparing the manual classification of sensory modalities with the classes returned by the automatic annotation.
The number of correctly assigned sensory modality schemes was 54 out of 133 (40,60%).

Table 4
Distribution of word pairs in Ullmann's schemes (Hong Kong museum).

	ADJ - NN	ADJ - - NN	ADJ - - - NN	VRB - NN
Touch ⟶ Taste	1	0	0	0
Touch ⟶ Smell	0	0	0	0
Touch ⟶ Hearing	0	0	0	0
Touch ⟶ Sight	0	5	8	0
Taste ⟶ Smell	2	0	0	0
Taste ⟶ Hearing	1	0	0	0
Taste ⟶ Sight	31	5	2	1
Smell ⟶ Hearing	1	0	0	0
Smell ⟶ Sight	8	0	1	0
Hearing ⟶ Sight	59	5	3	0
	103	15	14	1

Given the relevance of the syntactic patterns in the detection pipeline, we also report their distribution according to the syntactic scheme (the number of - indicate the distance between the nodes):

- Adjective - Noun: haptic ⟶ visual: 41 pairs (of which 5 synaesthetic metaphors, 13%)
- Adjective - Noun: haptic ⟶ taste: 1 pair (of which, 1 synaesthetic metaphor, 100%)
- Adjective - Noun: haptic ⟶ auditory: 1 pair (of which, 1 synaesthetic metaphor, 100%)
- Adjective - - Noun: haptic ⟶ visual: 3 pairs (of which, 3 synaesthetic metaphors, 100%)
- Adjective - - - Noun: haptic ⟶ visual: 8 pairs (of which, 2 synaesthetic metaphors, 25%)

The multi-class classification model suffers from the noise of the lexical resources employed, many related to the documented cross-modality of adjectives and nouns, errors in vocabulary sampling or annotator misunderstandings [17]. Despite this, sensory features remain essential for recognition.

Zero-shot classification The zero-shot model was tested on metaphorical and non-metaphorical pairs.
We tested the accuracy of the zero-shot classification model on a set of 40 metaphorical (20) and non-metaphorical (20) pairs mined from the Hong Kong museum's catalogue (issued from manual annotation). The results can be found in Table 5.
Moreover, the zero-shot classification model was evaluated also on a set of 63 metaphorical (34) and non-metaphorical (29) pairs provided by Su et. al [4]. While the latter dataset has not been extracted from the art domain, it provides the only annotated resource for English which belongs to a related domain, namely poetic expression.
For the Honk Kong museum, Precision (P) and recall (R) of the metaphorical pairs are:

- P = 100%
- R = 5,8%

Precision (P) and recall (R) of the non-metaphorical pairs:

- P = 100%
- R = 25%

For the Su et. all dataset (2019), Precision (P) and recall (R) of the non-metaphorical pairs are the following:

- P = 74%
- R = 100%

Precision (P) and recall (R) of the metaphorical pairs are:

- P = 79%
- R = 100%

As it can be observer from these data, the zero-shot classification model suffers from a very low recall score regarding the Hong Kong's pairs rather while it works well for the Chinese pairs. The recall percentage for the metaphorical pairs from the Hong Kong' dataset is 5,8% and for the Su et al. one is 100%. This disparity in scoring may be related with the presence of iconic metaphors in the Su et al.'s dataset (2019).

Discussion Considering the difficulties emerged in the application of the pipeline to real data, the preliminary results reported above suggest different research lines.
First of all, the quality of resources and their suitability for this task require further investigation. As acknowledged by the literature, in fact, the mapping of words onto sensory modality is not fully reliable, and is affected by the method by which the mapping has been obtained. Only in half of the cases, in fact, the sensory modality scheme has been correctly assigned by the multi-classifier, partly due to wrong mappings in the datasets employed for the task.
Secondly, the relationship with the models and resources for the detection and interpretation metaphors appears intricate. Metaphors are usually characterized by abstract concepts, while synaesthetic metaphors are intrinsically rooted in concreteness, being related with perception of the physical word through senses. The significance of the better performance of the zero-shot classification on the dataset of synaesthetic metaphors by [4] is difficult to assess, since this dataset has been partly obtained with synthetic methods from a corpus of occurrences extracted from a different, yet related domain, namely, poetry.
Finally, this preliminary investigation points out the importance of specific modalities. For example, if we observe the data reported in Table 4, which reports the sensory modality schemes of the candidate word pairs, the primary role of the Hearing-Sight scheme, and of Sight in general, clearly emerges. This prevalence is confirmed also by the manual annotation. On the one side, this represents an opportunity for creating alternative sensory experiences of art by replacing sight with hearing; other examples associated with the tactility of painting surfaces, provide a basis for enhancing the experience of art by touch (see the discussion in Section 3.1). On the other side, these data orient the research towards specific, more frequent patterns and schemes, suggesting that the creation and enhancement of resources should address these sensory modalities to improve the classification tasks.

Table 5
Metaphorical pairs from the Hong Kong catalogue with confidence intervals

Pair	Metaphorical/non-metaphorical	Confidence intervals
engaging gaze	non metaphorical	0.52
rhythmic movement	non metaphorical	0.87
rigorous strokes	non metaphorical	0.52
sweet smile	non metaphorical	0.63
rich image	metaphorical	0.81
rich shade	non metaphorical	0.55
rich brushstrokes	non metaphorical	0.54
nuanced depths	non metaphorical	0.83
brushstrokes crisp	non metaphorical	0.67
pleasant color	non metaphorical	0.62
warm hue	non metaphorical	0.54
delicate brushwork	non metaphorical	0.7
heavy brushwork	metaphorical	0.6
vigorous brushstrokes	non metaphorical	0.58
stronger taste	non metaphorical	0.54
denser form	non metaphorical	0.59
rough brushstrokes	non metaphorical	0.73
rough cut	non metaphorical	0.76
heavy form	metaphorical	0.86
crisp line	non metaphorical	0.58
black contrast	non metaphorical	69
modern painting	non metaphorical	78
black plain	non metaphorical	96
kind look	non metaphorical	61
red inscription	metaphorical	53
right border	non metaphorical	55
thick line	metaphorical	61
angular brushstrokes	non metaphorical	73
tall tree	non metaphorical	54
important building	non metaphorical	59
nuanced ink	non metaphorical	84
regular class	non metaphorical	85
rounded brush	metaphorical	53
dated works	non metaphorical	71
daily life	non metaphorical	97
solid background	non metaphorical	86
repetitive motif	metaphorical	88
physical principles	non metaphorical	99
maritime trade	non metaphorical	74
rare porcelain	non metaphorical	76
fibrous paper	non metaphorical	58

5. Conclusion

In this paper, we presented a preliminary model and pipeline for the detection and interpretation of synaesthetic metaphors in artwork description. In order to explore the occurrence and types of these metaphors in real data, we annotated a corpus of texts extracted from museum catalogues. Moreover, we designed a pipeline which leverages automatic methods for identifying synaesthetic metaphors based on syntactic, lexical and semantic features. This pipeline has been implemented with state of the art tools and evaluated on a set of real data. Although preliminary, this experiment confirms the relevance of this phenomenon and its potential for implementing alternative ways for experiencing art, in a universal access perspective.
For future research, we intend to improve the quality and coverage of the resources used for the classification of sensory modalities by crowdsourcing annotations on museum data. Also, we will investigate the emotional valence and range conveyed by synaesthetic metaphors, in order to explore their potential in a more comprehensive way.

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