DRS 2022
Bilbao 25th June — 3rd July

Method of mapping interdisciplinary research and practice at the intersection of biology and design

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https://doi.org/10.21606/drs.2022.XXX

Abstract: The research presented in this paper tackles the problem of terminological disharmony, specifically within the process of contextualising creative design practice informed by biological science and/or its applications. The study is implemented in three stages; corpus-based investigations of historical and current databases of text are used to assess the scope of biologically informed disciplines (BID) terminology. The results are analysed using statistical and qualitative methods and mapped against known academic domains. The resulting map is evaluated via the analysis and consequent positioning of practice-based biologically informed textile research. The findings suggest that the new approach mitigates the impact of terminological misappropriation in the design sector, by anchoring biologically informed design practice within an established academic disciplinary framework.

Keywords: Biodesign. Biomimetics, Bio-fabrication, research methods

1. Introduction

Biomimetics, biomimicry, biodesign, bionic etc. are all examples of terminology coined to describe emerging concepts for design and manufacture that have been inspired, informed, copied etc. from biology. The systematic explanation of biological phenomena using the principles of physics (biophysics) and subsequent application of findings into engineering design, was pioneered by polymath Otto Schmitt in the 1920's. Schmitt was interested in applying what he learned from his studies on the nervous system of squid into new technology. He did not devise a name for the practice of applied biophysics until the 1960's when he coined the term *biomimetic* to explain his approach to innovation. *Bionic* was another term created by Otto's peers at the US air-force who had gained interest in this space (J. M. Harkness, 2004).

Today, this idea has exceeded the boundaries of the natural sciences into every academic domain, including the applied arts. In 2021, it is not unusual for under-graduate and post-graduate design students, concerned with the environmental impacts of their practice, to experiment with the production of bio-polymers from food waste in their kitchens. How

would one classify this novel practice? Is it biodesign, bio-fabrication or biomimetics? Currently, the practice can be defined as any or all of these.

Bio- related terminology emerged organically in response to a surge in activity in the area, by the very researchers developing new knowledge (J. M. Harkness, 2004; Vincent, Julian FV, 2001; Pecman, 2014). New terminologies facilitate the dissemination of knowledge emerging from new interdisciplinary collaborations, they can also help establish the researcher's own position within research communities operating in this space (Gunnarsson, 2011). However, as the idea of learning from biology has spread to the wider range of academic domains, designers/ artists innovating within this space appropriate terms from scientific disciplines to define activity within their own domain; an act which itself introduces new layers of complexity to the terminology and its use.

As such, terminology containing the prefix bio- pertaining specifically to interdisciplinary activity centred on the biological sciences and their applications, is difficult to navigate, especially by researchers from non-scientific sectors. The presence of diverse meanings for a small number of terms (polysemy) is a systemic issue reported by scholars from both scientific disciplines (Lepora, Verschure and Prescott, 2013; Vincent, 2014; Vincent et al., 2006) and the humanities (Wahl, 2006; Iouguina, 2013; Kapsali, 2016). Iouguina (2013) proposed *Biologically Informed Discipline* (BID) as an umbrella term for the sector to consolidate the range of bio-related terminology and help mitigate ambiguity in communications.

The BID landscape was originally observed to be composed of two distinct areas, Wahl (2006). On one hand information from biology is applied to address the impact of manufactured problems on the Earth's geology and ecosystem, key texts describing this approach include Natural Capitalism: The Next Industrial Revolution' (Lovins and Hawken, 2013), Cradle to Cradle: Remaking the Way We Make Things (McDonough and Braungart, 2010), The Blue Economy (Pauli, 2010), Biomimicry: Innovation Inspired by Nature (Benyus, 2002) and Industrial Ecology (Lifset and Graedel, 2002).

On the other hand, biology is used to inform technological innovation mainly within the robotics and materials engineering disciplines (Lepora, Verschure and Prescott, 2013). Typically, multidisciplinary teams consisting of biologists and engineers exchange information using shared theories and practice. The discipline specific cultural and conceptual barriers between biology and engineering are overcome via a shared language of physics expressed in mathematics. The driver propelling this collaborative activity is expressed in terms of energy/ cost savings (Vincent,1997), in other words the study of biological systems holds blueprints for technology that delivers advanced functionality using less expensive materials and low energy processes.

Interestingly, both camps share the terms biomimetics and biomimicry, however, the words themselves carry significantly different meaning in each context. Iouguina, Dawson, Hallgrimsson and Smart (2014) devised a novel methodology to study this further. The team

combined lexical semantics with ethnography to the study the perceived difference between the two terms within relevant communities of practice. The research mapped the spectrum of semantic values attributed to the morpheme [-mimetic] by key actors from both the ecological and technological communities. The former reserve *biomimicry* to signify concepts driven by ecological imperatives and use *biomimetic* to distinguish technology focused actions. The later (technology focus) regard the two terms as identical from a semantic perspective.

This study builds on the lexical semantic approach developed by Iouguina et al., 2014 to study the breadth of bio- terminology with the aim to develop a synchronic, transparent framework for mapping the BID landscape and discourse at the intersections of biology and design.

2. Classification framework based on lexical semantics

Terminology, a sub-category of lexicology (Azimjanovna, 2020), is a relatively new area of study within linguistics. Lexicology focuses on the study of the nature and function of words as symbols and their relation to other words within the lexicon. Faber (2009) introduces a cognitive dimension, as such regards terminology as linguistic units which convey conceptual meaning within the framework of specialised knowledge texts to facilitate specific communication, translation and knowledge transfer between text users belonging to different language communities.

The rapid growth in scientific and technological knowledge, observed during the last century (Caso, 1980; Grene and Depew, 2004), has triggered a surge in the formation of novel terms to express new concepts, methods, materials and tools. The traditional method of coining scientific terms draws on Greek and Latin roots, however this is no-longer the case (Caso,1980). The formation of contemporary scientific terms is informed by internal and external factors, often in a chaotic and spontaneous manor (Azimjanovna, 2020) by scientists, who are not necessarily trained in the classics or linguistic theory and ‘work in fields of science that do not have a strong tradition of resorting to ancient languages’ (Caso, 1980).

From a morphological (or lexical) perspective, terms are composed of smaller lexical elements (morphemes) and phonemes (basic sound units). A morpheme is the smallest unit of language that has its own meaning, either a word or a part of a word: worker contains two morphemes: work and -er. Lexical semantics (Hanks, 2006; Cruse et al., 2002; Geeraerts, 2010) is concerned with the meaning of lexical units, specifically on the identification and explanation of word meaning via diachronic (how the meaning of words change over time) or synchronic (current) perspectives.

Faber (2009) notes that the theoretical proposals in the field of terminology have been mostly practice-based, arising from the elaboration of glossaries, specialized dictionaries and

terminological and translation resources (Faber, 2009), mainly by scholars in applied linguistics such as translation (Faber Benítez, 2009; Azimjanovna, 2020; Pecman, 2014).

New lexical units are created via word formation (WF); a specialised branch of language science which studies the patterns on which new words are formed (Marchand, 1969). Lexical units carry meaning(s) (concepts) as well as a syntactic valence (Faber, 2009). Lexicogenesis is the practice of making new word forms and meanings; regardless of whether the concept described is new or existing, it is expressed by a new or alternative lexical item (Geeraerts, 2010). Caso's (1980) view is that that lexicogenesis of scientific terms has had significant impact on the lexicon at large.

Faber (2009) describes systems formed of concepts relating to specific areas of human experience that provide the necessary contextual knowledge for our understanding of the world around us. This knowledge is referred to as domains (Langacker, 1987) or frames (Fillmore, 2006). A domain may be defined as any knowledge structure that is of relevance to the characterization of a certain meaning (Paradis, 2012); it can sometimes refer to the knowledge area itself, and other times, to the categories of concepts within the specialized field (Faber, 2009). On this basis, the mapping of relevant bio- morphemes against the established framework of 'academic' domains (Social, Formal, Natural, Applied Sciences, Arts and Humanities) can provide insight into the configuration of the wider BID landscape as well as the internal structure of individual sub-domains, this is the basic principle that underpins the concept for a new method of classifying practice in this space.

3. Methodology

Fabre (2009) advises that the approach to linguistic analysis of terminology should be lexically centred, usage based and focused on meaning and conceptual representation. As such, BID terminology is studied via formal (lexical) and semantic perspectives. Digital corpuses are used to access historic and synchronic data. Queries are conducted via web-based tools aligned to each specific corpus and results typically return concordance views such as KWIC (key word in context), frequency (a number signifying the total of instances of something that occurs in a corpus) and number of unique words (Hoffmann et al, 2008).

The objective of the initial corpus search is to identify the range of unique BID morphemes (terms containing the prefix bio-), this is achieved via the analysis of frequency and concordance displays of search results. Semantic analysis is conducted by grouping individual morphemes into conceptual clusters (domains). Mapping morphemes onto a well-established framework of academic domains provides a credible structure on which to position new BID domains to mitigate the ad-hoc manner in which these terms have emerged.

Further corpus queries are used to hone in on specific terms in order to clarify semantic value by analysing and comparing collocates, KWIC and concordance views of the data. This is especially useful to determine the semantic values of newer terms such as *bioart* and

biodesign that are not yet established within the wider lexicon or represented in a dictionary.

The outcomes from the analysis of data resulting from corpus queries are consolidated onto the BID map (BID individual morphemes plotted against academic domains). Five case studies from the textile sector are selected to test the relevance of the framework as an approach to mapping individual practice within the context of the disciplines that have informed them. The case studies selected share the topic of bio-informed innovation in textile design to provide a focus for this experiment.

3.1 Diachronic Study

The origin of the terms biomimetic(s) and bionic is widely reported (Harkness, 2004; Vincent et al., 2006; Kapsali, 2016), this specific action seeks evidence of the presence of BID morphemes via the analysis of academic texts from the British National Corpus (BNC) during 1960-1993. The BNC is a comprehensive collection of written and spoken language samples from a wide range of sources, such as regional and national newspapers, specialist journals, academic books, popular fiction, school and university essays. The BNC contains about 100 million words and was designed to represent a wide cross-section of British English, both spoken and written, from the late twentieth century.

Unique morphemes are identified via statistical and morphological analysis and compared chronologically across the periods 1960-74, 1975-84, 1985-93[1] to provide a view of the scope of BID terminology and its impact on the lexicon. A comparative analysis of the presence and/or appearance of novel BID morphemes, for each period, is performed between scientific and arts/ humanities genres of academic text for evidence of terminological transfer between domains.

3.2 Synchronic study

A current view of the range of BID terminology is studied via the analysis of synchronic, digital, web-based corpuses (iWeb and Wiki Corpus). The one hundred most common BID morphemes are identified using the approach described previously. The morphemes are grouped broadly into conceptual domains i.e. in categories that relate to specific aspects of the academic domain such as tools, materials, methods etc.

BID terminology is plotted against the established framework of academic domains to reveal a map of current activity and most importantly, interdisciplinary connections. The suitability of the map as an alternative approach to contextualising activity is tested via the analysis of design-led BID research on the topic of design.

[1] timeframes based on chronological framework of BNCweb

4. Findings

This section presents the results from the historic (1960s-1993) and synchronic (2020) study of BID terminology. The results of the experiments are limited by the nature of the corpuses, i.e. single language, selective texts. As such, outcomes are regarded as indicative rather than a definitive account of events and trends.

4.1 Diachronic study 1960-1963

An individual word query was performed for the expression [bio*], the expression was designed using the Simple Query Syntax (Hoffmann et al., 2008) where the symbol <*> functions as a wildcard denoting zero or more characters. For the purposes of this study, the wildcard was positioned after the prefix to request a search for word formations that begin with bio- and are followed by zero or more characters to return the widest possible range of BID terms.

Table 1 Chronological view of the total number of bio- related tokens and unique words from British National Corpus (BNC). Time period are based on the BNC chronological organisation of data.

Period	**Total tokens**	**Unique words**
1960-74	124	16
1975-84	591	46
1985-1993	8766	480

Additional search restrictions were set to focus on written texts across specific chronological periods; 1960-1974, 1975-1984, 1985-1993. The results revealed the total number of tokens or instances of word formations meeting the search criteria and unique words present within the range of tokens. A chronological view of total tokens and unique words is presented in table 1. The BNCweb *unique formation* function considers derivatives of the same root such as biologist and biologists as two individual word forms. As such, the number of unique forms as presented in table 1 is regarded as indicative, however the increase in total tokens suggest significant growth in terminological use from the mid 1980's until 1993 (inclusive) while the increase in unique words suggests impact on lexicon.

The most common unique words per period were identified using the BNCweb frequency function. These were further examined for common morphemes and merged; for example we combine the number of individual occurrences of the morpheme {biolog-} (i.e. biologists, biological with biologically). Morphemes concerning the term biology and its derivatives are consistent across all three periods. The morpheme {biograph*} (pertaining to the description of an individual's life) and all its derivatives were removed as they are outside the scope of the study.

Wordclouds are electronic images comprised of words from an electronic text or a series of texts. The size of each word within the image is scaled according to the frequency in which it is present within the electronic text. We accessed the *wordcloud.co.uk* generator to produce an image for each period studied. The images include the entire range of unique word formations from the period. Raw data from the results of the corpus searches were used. Terms omitted from the previous study are included (such as derivatives of {biograph-}) for context. The image for period 1985-93 omits 35 of the least frequent words due to image size restrictions. This is considered acceptable as the aim of this experiment is to visualise the increase in new bio- related terms. The resulting digital images from period 1960-74, 1975-84, 1985-93 are presented in figures 1a,b,c respectively.

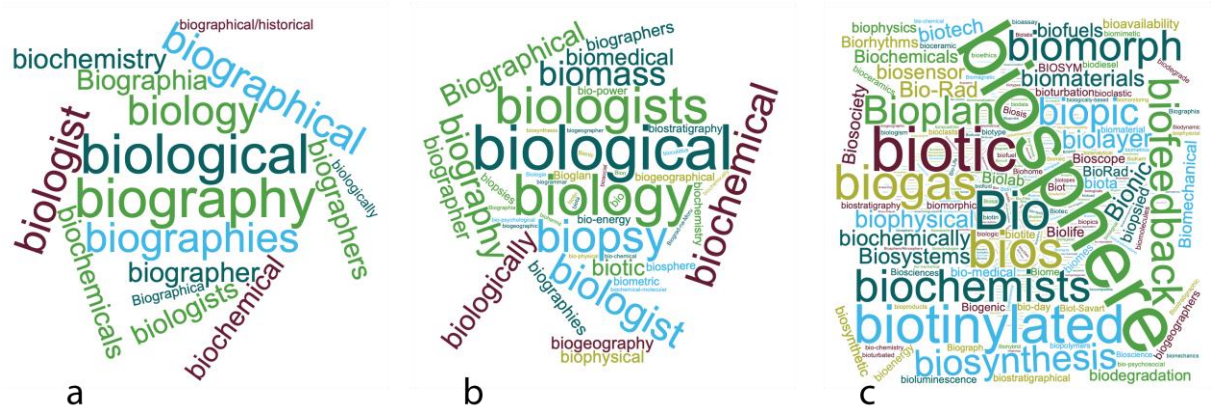

Figure 1 Wordcloud images generated using wordcloud.co.uk algorythm illustrate the breadth of bio- related terms as they appear within the BNC per chronological period a. 1960-74, b. 1975-84, c:1985-93. 'Biological' is the most common word from 1960-84 and 'biosphere' during 1985-83. The increase in word density indicates significant growth in bio-related terminology within the English lexicon from 1975to 1993.

4.2 Terminology transfer

The query [bio*] was repeated with additional restrictions designed to isolate use of the term within specific academic domain. Two genres[2] from different academic domains were selected for comparison 1. Natural sciences and engineering (Science) 2. Arts and Humanities (Arts). Figure 2 compares the number of tokens and unique word forms between the art and science genres chronologically. Derivatives of the morpheme [biograph-] feature heavily in the Arts genre, this data was omitted because it is outside the scope of the study.

The list of most frequently occurring terms per genre was analysed for common morphemes and combined using the approach described previously. The most frequent morphemes across the two genres per period are presented in figure 2. Morphemes from the Arts during periods 1960-84 do not feature in the graph because no relevant tokens appear during this period (i.e. morphemes that are not [biograph-]), however significant activity is noted in the following decade. Specifically, morphological derivatives of bio- directly related to the subject of biology feature prominently.

[2] Genres refer to sub-categories or discipline of a broader domain within the context of BNCweb

A new concordance was produced via a query for the expression [biolog*] restricted to written text within the Arts and Humanities genre during the period 1985-93. The results provided deeper insight into the context and use of the expression. Analysis of the data revealed discourse that draws together biological concepts with social and philosophical disciplines. Further details were obtained via the BNCweb distribution function which presents meta-data in terms of the text type, authorship and audience base. The results from the [biolog*] query reveal the textual domain of Belief and Thought as the primary context for relevant tokens, followed by the Arts and Social Science.

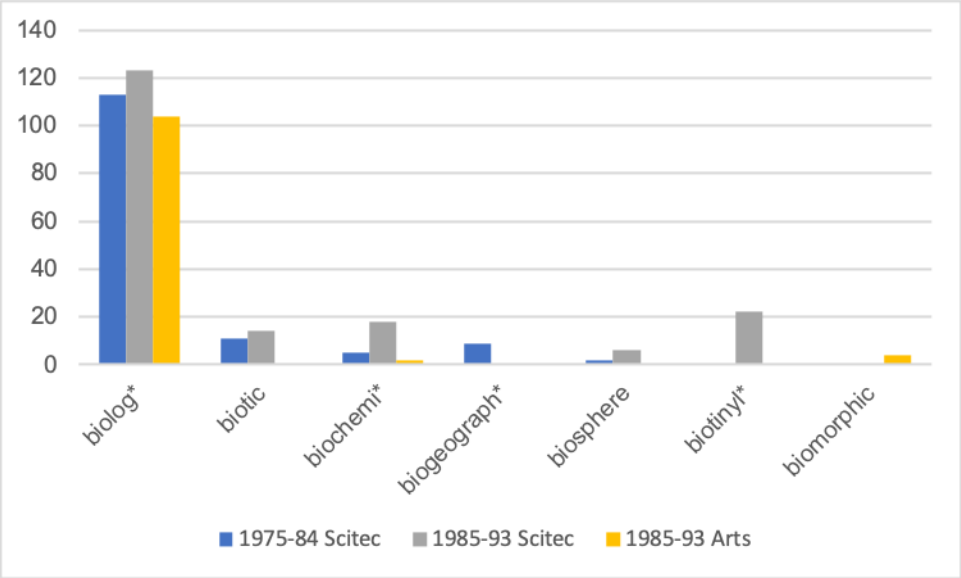

Figure 2 Graphic representation of most frequent bio- morphemes in chronological view according to genre from NBC. Bio-related terms do not feature in Art & Humanities related texts before 1985. From 1985 onwards biology is the most popular bio- related word followed by biomorphic and biochemistry in Art & Humanties texts.

4.3 Synchronic study

Wiki Corpus and iWeb were selected for synchronic study; the Wiki Corpus contains the full text of Wikipedia comprising of about 1.9 billion words and 4.4 million web pages. iWeb consists of approximately 95,000 websites, selected primarily by scale (the size of each website include in the corpus comprises of an average of 240 web pages and 145,000 words). The limitation of both corpuses is that the content is intended for communication purposes and is either crowdsourced (Wikipedia) or curated by individuals or organisations (websites), as such use of language and credibility of contents are problematic. Nonetheless, Wikipedia and the wider web are democratic and dynamic platforms used by many to share knowledge including those working within BID. For the purposes of this study, the Wiki and iWeb Corpus present ideal data sources due to their considerable size and breadth.

The same protocol is used for the query expression [bio*] as per the diachronic study. The resulting total number of tokens and unique words returned, are presented in table 2. The same caveat regarding the identification of ‘unique’ words by the algorithm performing the

analysis as per previous study, applies. As such, the number of unique forms presented in table 2 should be regarded as an approximation of size rather than definitive value.

Table 2 Chronological view of the total number of bio- related tokens and unique words from Wiki Corpus and iWeb corpus accessed on the 26th of October 2020.

corpus	**Total tokens**	**Unique words**
Wiki	490,570	6,531
iWeb	1,987,972	8,766

The 100 most frequent word forms from both corpuses were analysed to identify common roots; terms referring to biographical concepts were omitted such as biopic (neologism referring to a biographical film). Terms relating to the title or characters of games were also removed from the data such as BIOWARE. Although [biolog-] was the most common morpheme, it is omitted from the data presented in figure 3 because the total number of tokens was in excess of seven times the total of the second most common morpheme [biochem-] and as such skewed the graphical representation of data related to the other terms. Figure 3 shows the resulting most frequent bio- terms after biology-, it is worth noting that this is a snapshot of word frequency specific to the date and time accessed, as such, this list is expected to change and vary with time.

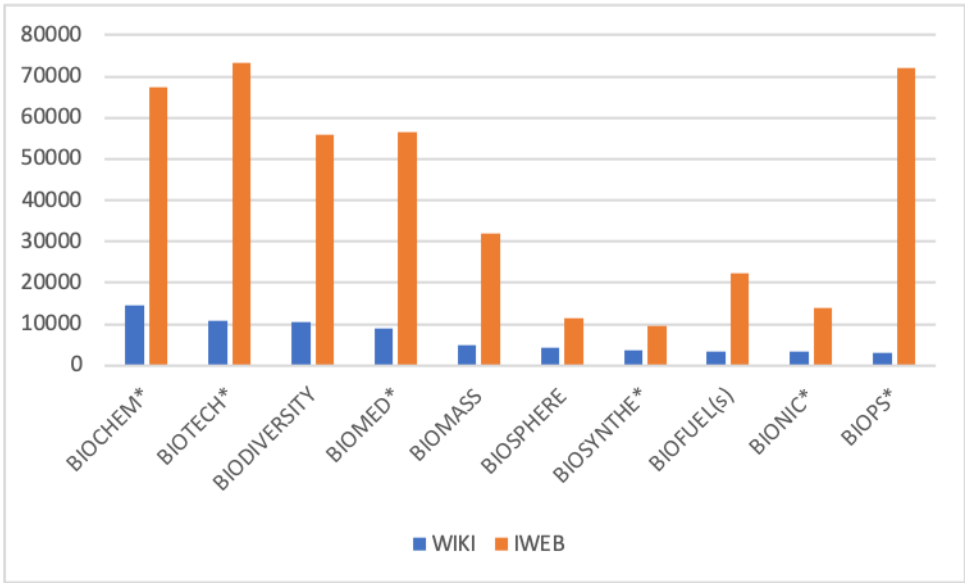

Figure 3 List of most popular bio-related morphemes per corpus as accessed on the 26th of October 2020

The analysis of the most common BID terms reveals significant impact on the lexicon of life and applied sciences. However, specific terms relating to the intersection with the Arts and Humanities such as bioart and biodesign, do not feature within the results. The only exception being *bioethics* (which resides within the discipline of philosophy.

Another observation is that bionic(s) is more commonly present within the corpuses than biomimetic(s) and biomimicry. Further insight was obtained via a new Wiki corpus query for the terms [biomimetic] and [biomimicry]. The resulting concordance data indicate that *biomimetics* is used as a general descriptor of process within technology focused texts, while the *biomimicry* is used within the context of sustainability and circular economy. This supports the findings of Wahl (2006) and Iouguina et al (2014) as discussed in section 1.

Figure 4: Map of BID landscape based on 100 most common bio-morphemes with the addition of Biodesign and Bioart

5. A framework for mapping design research in BID based on conceptual domains

Concepts form systems that describe human experience and provide a framework for contextual knowledge that enable us to make sense of the world around us (Faber, 2009). By drawing on the established system of academic domains we create a framework for mapping the range of BID activity and plot the 100 most common current bio- morphemes against this framework. The resulting map is presented in figure 4. This image (fig 4) presents insight into the breadth of interdisciplinary within this topic; BID practice intersects every aspect of the sciences. We are able to distinguish terms coined to express new concepts formed by the combination of two or more academic disciplines and/or sub disciplines, the primary being biology.

5.1 Bio- art and design

This section reviews the emerging spaces of *bioart* and *biodesign* within the context of the experimental framework described earlier (fig. 4). It is worth noting that at the time of access (26/9/2020) a search of physical dictionaries and digital lexical databases resulted in no credible definitions for the terms. The semantic values of [bioart] and [biodesign] were investigated using the Wiki Corpus with a focus on collocate and KWIC data views.

The [biodesign] collocate query sought out words that immediately follow the term. The query returned the word 'institute' in the majority of instances, this was also evident in the KWIC (key words in context) view of the data. The primary purpose of 'Biodesign institutes', as suggested from the data is health and wellbeing. However, within the design research communities, biodesign signifies 'the incorporation of living organisms as essential components, enhancing the function of the finished work. It goes beyond mimicry to integration, dissolving boundaries and synthesising new hybrid typologies' (Myers, 2012).

The [bioart] query revealed words: 'art', 'project' and 'practice' as the most popular collocates that follow the term. The KWIC display returned words such as 'practitioners', 'project', 'practice' and 'cell culture'. *Bioart* is regarded as a specialist form of art practice where humans work with live tissues, bacteria, living organisms, and life processes in general. This type of practice involves collaboration with the life sciences and/or medical disciplines. Techniques from various aspects of biotechnology are applied to the creation of artworks, these include tissue engineering, cloning and genetic engineering.

The corpus study suggests that bioart and biodesign have similar semantic values, in that techniques from biotechnology are applied to the creation of practice, be it for innovation, speculation (design) or provocation, social commentary, entertainment etc. Drawing on the academic domain-based framework described earlier, it is possible to position biodesign and bioart within the BID landscape as illustrated in figure 4.

Further analysis of specific design case studies seek to interrogate the meaning and structure of biodesign as an individual domain and consequently, evaluate the proposed BID framework as a tool for analysing and mapping individual research practice.

5. 2 Mapping BID design case studies

The following five case studies were selected to test the mapping framework on the basis that the research is practice based, biologically informed and led by designers working with textiles. The work is classified using the framework [project title/ description] combines [bio-related domain 1], [academic domain 2]… with [specific textile discipline] *to inform* [specific design practice] via [x,y,z] methods. Square brackets, in this case, are used to illustrate specific elements of the data to simplify analysis and guide mapping. Where possible, we include motivation related to the development of the work (i.e. technology or ecologically driven)

1. Tissue Engineered Textiles (TET) combines [tissue engineering] with [embroidery] to inform [a new approach to growing materials for fashion applications]. This was achieved via [creating embroidered structures using yarns made from bio-compatible polymers and tissues engineering techniques, within a lab setting, to seed and grow cells on the textile scaffolds] (Congdon, 2020). The driver for this research was technology driven, to understand if and how the disciplines involved can generate new knowledge.
2. Programmable Knitting (PK): combines [botany] with [knit design] to inform [a method of introducing intentional, autonomous, shape change behaviour to textiles]. This was achieved via [the application of knowledge from botany explaining the hygroscopic mechanism of pinecone to inform the yarn specification and knit structure] (Scott, 2015). The driver for this research was ecological [biosystem] and technology driven, to understand if and how biology can inform the non- electronic design of textiles with shape changing properties.
3. Biocouture (BC)[3]: combines [fermentation] with [sheet textile design] to inform [novel approaches to creating compostable sheet materials for clothing]. This was achieved via [experimenting with the mass of bacterial cellulose, by-product of Kombucha manufacture, to produce sheets cellulose material and process it into garments using adapted construction and textile manipulation techniques] (Lee, n/d). The driver for this research was ecologically driven [biosystem], to understand if and how biotechnology can teach us new, sustainable ways of making apparel products.
4. Mycelium Textiles (MT): combines [mycology] with [sheet textile design] *to inform* [the creation of a novel compostable sheet material for application in apparel]. This was achieved via [using agricultural waste streams and fungal biotechnology to create novel sheet materials](Bolt Threads, n/d). The driver for this research was ecologically driven [biosystem], to understand how fungal biotechnology can teach us how to make biodegradable materials for apparel using agricultural waste streams.
5. Hygroscopic Textiles (HT): combines [botany and materials engineering] with [fibre and yarn design] *to inform* [a method of introducing intentional, autonomous, shape change behaviour to textiles]. This was achieved via [the application of knowledge from botany explaining the hygroscopic mechanism of a broad range of seed dispersal mechanisms such as the pinecone to inform the design of fibres and yarns] (Kapsali, 2009). The driver for this research was and technology driven, to understand if and how biology can inform the non- electronic design of textiles with shape changing properties.

Each case is plotted onto the BID map as illustrated in figure 5. Domains not relevant to the study were removed for simplicity. The resulting map reveals a complex network of

[3] This project was funded by the Arts and Humanities Research Council (AHRC) reference: AH/D504015/1.

interdisciplinary activity indicating how the design sector interfaces with bio- related disciplines. The map suggests that design practice does not exclusively interface with biotechnology for the production of materials. Instead, an alternative pocket of activity draws on knowledge of materials and structures from biology to inform design with materials and processes typical to the textile sector; indicating at least two distinct areas of practice.

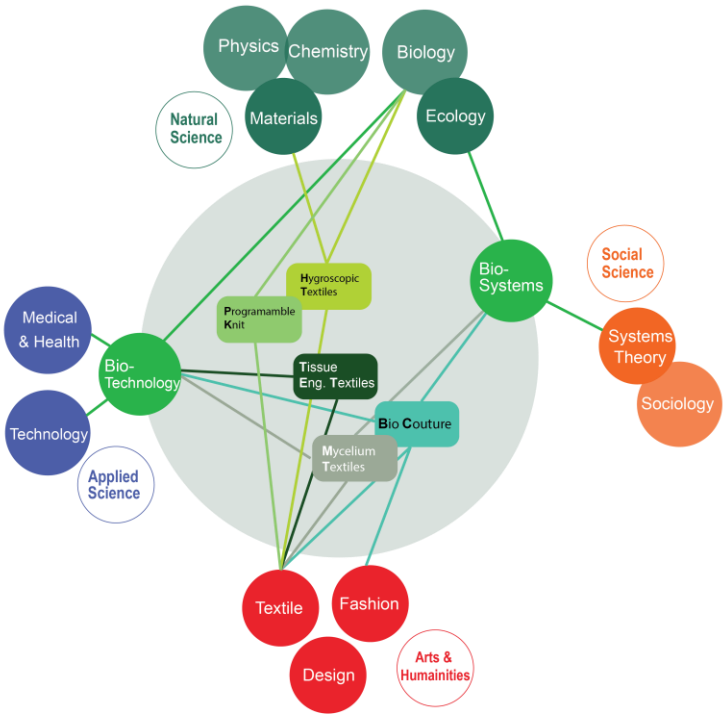

Figure 5 Map of BID landscape including five textile design based case studies: TET=Tissue Engineered Textiles, PK= Programmable Knit, BC= Biocouture, HT= Hygroscopic textiles, MT= Mycelium Textiles

Figure 5 also links some of the practice described in the case studies (BC, MT, PK) to work falling within bio-system*, an area of interdisciplinary practice that draws upon systems thinking from Social Science with Ecology, a sub-discipline of Biology specifically to address the environmental impacts of mankind. Concepts emerging from this space have informed alternative economical models such as cradle to cradle, circular economy. The same area broadly termed *biomimicry* as discussed in section 1. Although not all cases reviewed featured sustainability as a driver, this does not mean that the work is void of environmental concerns.

6. Conclusion

This study presents a novel approach to mapping the area of BID based on linguistic analysis of terminology pertaining to the field. Corpus based methods aided the historical study of bio- related morphemes and revealed a sharp increase of new terms during 1985-93 in the

United Kingdom. Evidence of BID terminology transfer was observed from natural sciences to the humanities during the same period and geographical region.

Corpus searches also enabled the identification of the most the common synchronic BID morphemes, these provided a basis for lexical and semantic analysis. Specifically, the identification of conceptual domains and their structure. BID conceptual domains were plotted against the known and established framework of academic disciplines, this revealed a complex web of interactions between all disciplines.

The semantic differences between bio -mimetic(s), -mimicry were challenged during the evaluation of the proposed mapping system. Within this context, the terms appear to offer no useful information or insight. The proposed domain-based framework enables the positioning of research and practice within a network of known and established disciplines in a way that provides a transparent and evidence based basis for the development of new practice, void of buzzwords.

The mapping system was adapted to include biodesign and bioart. A deeper analysis of the terms via corpus-linguistics challenged the semantic properties of each term. Honing in on the biodesign space revealed a much different picture to the sematic value indicated by the corpus search results.

Five BID textile design case studies were selected to test the proposed mapping system of and experimental framework. The findings revealed a very complex system of interactions between textile design and biological disciplines in their broadest sense. For example, we identified two distinct areas of practice; one that draws on the materials and tools of biotechnology to produce new materials, the other draws on knowledge emerging from the study of biological materials and structures to inform the design of conventional textiles.

The findings also provide some clarity in relation to the previous division of the BID landscape in terms of biomimetic and biomimicry. The area currently claimed by the term biomimicry, to denote actions driven by environmental concerns, is actually informed by interdisciplinary thinking from the 1970's (Papanek, Fuller, 1971 and Todd, Todd. 1984), that drew on ecology as a paradigm for sustainable communities and economies.

This study suggests that we should regard the BID landscape as a spectrum composed of a highly complex network of interdisciplinary actions. The relationship between the natural sciences and design would benefit from transparency in terms of interdisciplinary interactions. Specifically, clear links to contributing theoretical, conceptual and methodological frameworks should factor in the analysis and classification of work. This would not only raise the profile of the role and value of design within this context but could also set foundations for enhanced knowledge exchange between the arts and sciences.

Acknowledgements: This paper and the research behind it would not have been possible without the exceptional support of my colleagues Dr Cathryn Hall, Dr Kate Goldsworthy (co-director, Centre for Sustainable Design, University of the Arts London) and Professor Carole Collet (Director, CSM LVMH Sustainable Innovation, University of

the Arts London) for challenging and insightful discussions on circular and sustainable design within the creative sector. I would also like to thank the biologically inspired textiles advisory group for their contributions to discussions on this topic. Finally I would like to acknowledge the AHRC for funding this work (grant AH/T006412/1) and the University of the Arts London for hosting the research.

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