

Cataloguing Creative Informatics Projects: First Report (2018 - 2020)

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This work is the result of a large collaborative effort over more than two years. We wish to clearly acknowledge various contributions to the project, analyses and final report. The research was jointly-led and first-authored by Chris Elsdon and Susan Lechelt. They were directly supported by fellow research associates Adam Jenkins, Ingi Helgason, Inge Panneels and Pip Thornton in coding and analysing projects included in the Catalogue. All the projects in this Catalogue have been supported and funded by the Creative Informatics delivery team, who manage advertisement, applications, governance, funding and reporting of the projects. In particular, Anna Orme serves as our lead Evaluation Officer, and has been instrumental in soliciting and collecting the application and project reports upon which this research is based. Finally, we have been supported throughout by the academic Directorate of the Creative Informatics cluster, in particular Michael Rovatsos, who have provided invaluable advice, guidance and editorial insights on the research process, and final report presented here. This work is funded by the AHRC Creative Industries Clusters Programme (Award Reference AH/S002782/1), with support from the Scottish Funding Council and the Edinburgh and South East Scotland City Region Deal.

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1. Executive Summary

Creative Informatics is a research and development programme that supports work across Edinburgh's Creative Industries engaging with Data-Driven Innovation (DDI) - a cornerstone of the UK's industrial strategy for growth in the digital economy. This 5-year project supports a vast array of individuals and projects in the Creative Industries in engaging with DDI, through offering them funding and access to upskilling initiatives. The programme includes providing monetary support for individuals and Small and Medium Enterprises (SMEs) working in the Creative Industries as *'Resident Entrepreneurs'* – to develop new data-driven services and products; *'Challenge Projects'* – where creative and cultural organisations present challenges in need of a data-driven or digital solution; and *Connected Innovators* – an opportunity to support emerging leaders to advance their careers and businesses through data-driven innovation.

Over its five-year lifespan, Creative Informatics plans to fund more than 100 projects that engage with real world challenges in the Creative Industries. Projects can span multiple contexts and disciplines – all of the Creative Industries and all manner of digital technology; some last only 3 months, others can take up to 2 years; some will succeed and rapidly gain external investment, others will quickly pivot away from their original ideas, or will not be taken any further after the funding period. This presents a vast and demanding opportunity for academic research. As researchers, we sought a way to make sense of this varied array through a process of cataloguing the funded projects.

Focussing on projects funded and initiated in the first two years of the Creative Informatics cluster, we have systematically catalogued 44 of the projects that Creative Informatics has funded, based on their initial (and extensive) funding applications. These applications have to be read in their original, aspirational, context - as presenting a case for receiving funding. However, there is much to learn from *how* such a wide range of projects envision DDI in the Creative Industries. As such the Catalogue demonstrates the potential breadth of data-driven innovation in the Creative Industries.

This report offers an overview of the various technologies underpinning the funded Creative Informatics projects, and crucially, the different forms of data upon which they rely. We are also able to map a range of application areas, and identify five overarching challenges that projects aim to address: **1)** Developing new tools and interfaces; **2)** Supporting others' creative practice and skills; **3)** Addressing societal challenges through creative work; **4)** Exploring new data-driven techniques; and **5)** Building data-driven economies. Furthermore, through this coding and analysis, we identify how the projects relate to four core promises of the Creative Informatics cluster: from revealing and developing new business models, and engagement with new audiences and markets, through to unlocking hidden value in archives and data sets, and supporting new modalities of experience.

We also closely consider the unique facets of digital transformations within the Creative Industries, noting how numerous projects are centred on supporting collaboration, and building data-driven tools to support other creative practices and services. Several of the projects also foreground more creative and ethical approaches to data and technology than can be seen in other sectors. Nonetheless, our critical analysis also identifies a number of emerging tensions in the pursuit of data-driven innovation in the Creative Industries. While clearly there are numerous potential economic benefits to be realised through data-driven

approaches, this appears to depend on being able to formalise, abstract and modularise creative practices and services. This can make creative work more efficient, accessible and interoperable, but may be in tension with the flexibility and generative, non-linear nature of creative practices. Similarly, we question how new technologies and a reliance on generating and managing data may shift power and ultimately change roles in the Creative Industries as they become increasingly intertwined with digital economies.

Finally, we are using the Catalogue as a starting point to surface and answer new empirical research questions for Creative Informatics, which we hope could also be used to inform broader funding priorities in the future. Specifically, these include: how new technologies are working to enable new forms of work and practice; whether there are wholly new kinds of business models being developed through Creative Informatics; and the implications, legal and commercial, of how various forms of data in the Creative Industries are conceptualised and defined.

Cataloguing Creative Informatics projects is an ongoing process as funded participants complete their projects, and new proposals are funded. We expect to produce similar reports through to the end of the Creative Informatics programme. However, we hope by sharing our progress thus far, others may benefit from understanding our methodological approach, and the numerous research questions and challenges raised in this work.

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2. Creative Informatics Overview

This section provides an overview of the [Creative Informatics](#) programme in order to provide context for the Cataloguing work and insights included in this document.

The Creative Industries have been defined by the UK government's Department for Digital, Culture, Media & Sport as "*those industries which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property*"¹. Specifically, these include: advertising and marketing; architecture; crafts; product design, graphic design and fashion design; film, TV, video, radio and photography; IT, software, video games and computer services; publishing and translation; museums, galleries and libraries; and music, performing arts, visual arts and cultural education. Edinburgh's Creative Industries cluster has a vibrant creative and technology culture and is characterised by proactive networks across the high growth data/tech industry, a lively design and advertising sector, the largest concentration of major festivals in the world, and the highest cultural employment in the UK. Creative Informatics is a partnership between the University of Edinburgh, Edinburgh Napier University, CodeBase and Creative Edinburgh, funded by the AHRC Creative Industries Clusters Programme, with support from the Scottish Funding Council and the Edinburgh and South East Scotland City Region Deal. The project aims to grow Edinburgh's Creative Industries cluster, by increasing the number of existing businesses and creative entrepreneurs who can confidently innovate with data, thus building a cluster in which creatives across the sector are in the driving seat of Data-Driven Innovation (DDI). The objectives of Creative Informatics are:

1. To make Edinburgh a world class centre for creative talent who can lead data-driven innovation in the Creative Industries.

Creative Informatics includes three people-based programmes aimed at developing local talent: **Creative Bridge**, the **Resident Entrepreneur (RE)** programme and the **Connected Innovators** programme. Creative Bridge is a pre-accelerator course aimed at enabling creative entrepreneurs to build and scale significant new enterprises, and increase the confidence of creatives in corporate and freelance environments to help their colleagues and clients better understand the value of creativity. The Resident Entrepreneur (RE) programme financially supports individual creative entrepreneurs or small businesses by providing them with grants of up to £12,000 to develop new products or services using data or data-driven technologies. The Connected Innovators programme provides emerging leaders in the cluster with funding of up to £10,000 to support them in developing a specific area of their creative practice or business using data or data-driven technology.

2. To develop new data-driven products and services directed to audience engagement and new modalities of experience and to unlock value in archives and data sets.

We achieve this objective through R&D projects. **Challenge Projects** involve both creative and cultural institutions as "challenge holders" and creative practitioners as "challenge responders". In Challenge Projects, challenge holders pose a fundamental, data-driven challenge they are facing and challenge responders are offered up to £20,000 for research and development that answers the challenge. **Horizon Projects** are defined by the academic

¹ <https://www.gov.uk/government/publications/creative-industries-economic-estimates-methodology>

team based on emerging research and technology with potential for innovation in the Creative Industries. **Creative Informatics Labs and Studios** allow the cluster to network and collaborate, while experimenting and exploring technologies to inspire new uses and new product development. Many of the funded projects are expected to lead to Minimum Viable Products which will be presented to investor communities. In other cases, R&D projects will spark ideas and build capacity for future product development.

3. To develop new business models for the Creative Industries

Partnerships formed through R&D projects and the people-based programmes can draw on a range of academic expertise to support the development of new business models, including creative entrepreneurship, IP and technology law, digital cultural heritage, ethics, design and informatics and understanding of new transaction technologies (crowd-financing, micro-payments, cryptocurrencies). Creative entrepreneurs can thus develop radical new products and services, whilst understanding the opportunities and ensuring that social interests are safeguarded. Creative Bridge also prepares entrepreneurs for opportunities and challenges linked to new models for securing finance and revenue.

4. To develop audiences, markets and networks nationally and internationally to increase the economic growth of the Edinburgh cluster.

Challenge and Horizon projects develop engagement with and access to new local and global audiences and markets through DDI. Data-driven solutions for adapting and distributing content, aim to open up new international market opportunities for a range of Creative Industries. We hope to inspire companies to seek international markets by helping them build or extend international networks of partner organisations through showcase events and learn from the experience of local companies who have already reached global markets, as well as inspiring international industry leaders and investors.

3. Introduction to Cataloguing and the Report

The Creative Informatics Catalogue is an effort to formulate an empirically and practically useful overview of the projects funded by Creative Informatics. The Catalogue also aims to be an evolving, searchable database that can serve as a starting point for deeper empirical research and analysis. In this report, we present an overview of the Cataloguing work we carried out from 2018 to the end of 2020. This comprises methodical coding, affinity mapping and thematic analysis of documents related to three of our funded programmes described in the previous section: Challenge Projects, Resident Entrepreneurs and Connected Innovators. We chose to analyse projects related to these three programmes, as they offer funding to creative practitioners to lead on a substantial data-driven project, for funding of at least £10,000, and over at least several months.

Specifically, we have coded and analysed the successful funding applications for these programmes; these comprise standardised application forms that the successfully funded projects filled out in their bids to receive the funding. To date, we have completed coding and analysis for all successful funding application documents related to these strands submitted up to October 2020, comprising a total of 44 funded projects: 27 Resident Entrepreneur projects, 8 Challenge projects and 9 Connected Innovators projects. The applications themselves are extensive, and in particular ask applicants not only to describe their planned projects, but also to articulate how their projects meet various aspirations of the Creative Informatics cluster. They hence provide a common baseline by which to map a great range of otherwise distinct projects. Pragmatically, we have chosen to focus only on successfully funded projects as projects that have clearly articulated their aims (in order to be funded), and which we can subsequently follow up, as projects provide additional reports, demonstrations and engage more directly with the research team. These follow-ups will be the subject of future reports as the projects progress.

Using their funding applications as a baseline, we have coded for how the projects propose to engage with: key technologies, kinds of creative data, varied subject and application areas, and the proposed values and benefits of each project (e.g. Economic, Social, Cultural, Environmental). We have also analysed how the projects engage with the four core Creative Informatics themes: Unlocking the Value of Hidden Archives and Data Sets; Revealing and Developing New Business Models; Access and Engagement to New Audiences and Markets; Supporting the Development of New modalities of Experience.

In this report, we present an overview of our methodological approach, the findings from our analysis of the data so far, and questions to support a discussion about the limitations and future of the Creative Informatics Catalogue.

4. Methodological Approach

This section describes our methodological approach for coding and analysing our dataset. We first describe the dataset and our first attempt at open coding. We then describe the codebook we created based on our reflections, and our second, methodical process of coding and validating the data. Finally, we describe our methods for analysing the coded data and discuss some of the limitations/implications of the dataset.

4.1. The dataset

The Catalogue dataset comprises the successful funding applications submitted for the Resident Entrepreneur, Challenge and Creative Innovator strands, and specifically the applicants' responses to questions on the application form asking them to describe the proposed project. The responses to these questions include: overviews of the project idea, the work packages involved, how the project engages with the four key Creative Informatics themes and how the project makes use of data and technology. Currently, the dataset includes the submitted applications from the 44 projects that have been funded until October 2020, specifically: 27 Resident Entrepreneur projects; 8 Challenge projects; and 9 Creative Innovators projects.

4.2. Initial open coding and reflection

Our first step in analysing this data was to adopt an open coding approach. In this step, for each of the 44 applications, the applications were summarised in a spreadsheet using: a 100-word synopsis of the project, keywords that could be used to describe the project, descriptions of the key technologies/data the project was using and the Creative Industries the project was associated with. Following this process, SL² and CE met to discuss this data and reflect on how informative the categories and keywords chosen to code for were. During these meetings a more rigorous and informative protocol was developed, with more coding categories and detailed descriptions for each coding category. For example, it was discussed what categories might be used to more descriptively describe the data in order to represent a richer description of how the projects were engaging with data-driven innovation.

4.3. Coding protocol and use of NVivo

For the next phase, the application form data was transferred to the NVivo software - which enables coding to be carried out directly in the original documents (in this case PDFs including the relevant questions from the original applications). Based on the discussions in the open coding phase, a detailed codebook was created to guide the coding of the data. The codebook lists all of the categories to be coded for, together with a description of the category, instructions for how to code them, and relevant examples from the Creative Informatics dataset. There are 8 categories in total, comprising 4 open categories, and 4 fixed categories.

² The three main contributors to the analysis are described throughout the report using their initials: Susan Lechelt (SL), Chris Elsdon (CE) and Adam Jenkins (AJ).

The open categories enable the coder to add new codes within them, whereas the fixed categories have set codes that the coder must select from.

The four **open** categories are as follows:

- **Key technologies:** This is aimed at capturing the key ways in which each project uses/innovates a particular technology or technological method. Examples of codes in this category include Blockchain or Artificial Intelligence.
- **Domain data type:** This is aimed at capturing the purpose and context of the data being used; examples of codes in this category include Donations Data and Audience Data.
- **Raw data format:** This is aimed at capturing the specific formats of data that the project proposes to use (e.g. 3D scans, Text and Pos-tagged data). This category is under-represented in the Catalogue, as the project applications do not tend to describe the data formats they plan on using specifically. It is not included in this analysis.
- **Subject keywords:** This category includes keywords other than data and technology. This was developed as an open-ended category to enable the unique features of each project to also be included in the analysis. These keywords may address, for example: the domain of the project (e.g. heritage, health, education, festivals etc.), particular practices or methods that the project is using (e.g. image cropping, sound production, participatory design) or the key challenges the project is addressing (e.g. choice paralysis, accessibility, sustainability).

The codebook also includes four **fixed** categories where a number of pre-set options exist to be coded from, based on questions that were directly asked of applicants when they applied for funding. These are:

- **Creative Informatics themes:** This category codes for explicit answers by the applicants to the questions of what Creative Informatics themes they will engage with in their proposed work. Most applications assert that their project engages with more than one Creative Informatics theme. The themes are:
 - Unlocking the value of hidden archives and datasets
 - Revealing and developing new business models
 - Access and engagement to new audiences and markets
 - Supporting the development of new modalities of experience
- **Relevant Creative Industries:** This category codes for which Creative Industries each project is relevant to, as inferred from the application. The codes are based on DCMS Creative Sector categories and include: *{Advertising and Marketing; Architecture; Crafts; Film, TV, video, radio and photography; IT, software, video games and computer services; Museums, galleries and libraries; Music, performing arts, visual arts and cultural education; Product design, graphic design and fashion design; and Publishing and translation}*.
- **Primary values:** *{Economic; Environmental; Social; Cultural}* This category aims to capture the forms of value that the project aims to produce - we are interested in economic, environmental, social and cultural value.

- **Intended Innovative Project Output:** {*Audience Experience; Business Model; Data-Driven Method; Product; Service*} This category is aimed at capturing the form of innovation that the project aims to achieve; the analysis of this category is not included in this report.

4.4. Final coding process & inter-rater reliability

After the data was transferred to NVivo and the codebook was developed, AJ coded all of the data according to the codebook. CE and SL wrote synopses and critical reflections for each project. After AJ completed the coding CE and SL checked all of the codes, noted disagreements and suggested changes to the codes for consistency. They then all met together to discuss and resolve the discrepancies and disagreements.

4.5. Affinity mapping and thematic analysis

Following coding, SL and CE carried out two forms of qualitative analysis: affinity mapping of the open categories and thematic analysis of the a priori categories.

- **Affinity mapping of the open categories:** Affinity mapping³ was used on the open categories (i.e. subject keywords, key technologies and domain data type), in order to identify initial patterns, commonalities and points of interest between projects. Specifically, this was done by placing all codes on a digital whiteboard and collaboratively grouping them together with/underneath related codes. This is presented in the form of figures, on pages 12-18.
- **Thematic analysis of the a priori (deductive) categories:** Thematic analysis⁴ was carried out on the categories containing fixed codes - i.e. the Creative Informatics themes, primary values, relevant Creative Industries and intended innovative project output. This was done by looking at the data highlighted by the codes, grouping it together, and attempting to find deeper levels of meaning within the groups. Each of the fixed categories can give rise to a large number of research questions. In this report, we present a subset of our analysis so far, focusing on answering the questions: how are the projects we fund actually proposing to address the Creative Informatics themes? How are the projects proposing to look beyond economic value? How is Data-Driven Innovation (DDI) proposed to generate economic value in the Cultural and Creative Industries? This analysis can be found on pages 19-27.

³ Lucero A. (2015) Using Affinity Diagrams to Evaluate Interactive Prototypes. In: Abascal J., Barbosa S., Fetter M., Gross T., Palanque P., Winckler M. (eds) Human-Computer Interaction – INTERACT 2015. INTERACT 2015. Lecture Notes in Computer Science, vol 9297. Springer, Cham.
https://doi.org/10.1007/978-3-319-22668-2_19

⁴ Clarke, V., & Braun, V. (2014). Thematic analysis. In *Encyclopedia of critical psychology* (pp. 1947-1952). Springer, New York, NY.

4.6. Methodological implications and limitations

There are some important limitations to the data and analysis:

- It is based on funding applications. This data reflects what projects *propose* to do. While this can change during a project, the current analysis does not account for these changes.
- The focus is on analysing the specific projects, rather than the individuals and companies undertaking them. This is because individuals may pursue multiple projects within Creative Informatics, and their overall aims may go beyond a single project.
- In our analysis, we have found that some applicants are able to articulate technological innovation more clearly than others, and therefore may be over-represented in coding.
- This is an interpretive qualitative coding exercise where we have prioritised understanding the breadth of topics, technologies and data in a very heterogeneous set of projects, rather than attempting to count or formally measure these.

5. Affinity Mapping the Projects

In this section, we present figures demonstrating our affinity mapping of the codes associated with the open categories of: 1) key technologies; 2) data domains; and 3) subject keywords.

5.1. Key Technologies

For each project, we coded the primary technologies that the project planned to engage with. We coded this category inductively, using the terms the applicants used in their applications as far as possible. We focused especially on the technology that was the focus of the innovation, rather than every technology a project proposed to use. After coding, we then undertook affinity mapping of these codes to identify related clusters of technologies. These clusters are represented in Figure 1.

Our affinity mapping process led to the identification of 7 clusters, representing the overarching categories of innovative technologies used. These are as follows:

1. Machine learning and artificial intelligence, including, but not limited to, natural language processing, neural networks, deep learning and generative algorithms
2. Sound techniques, including data sonification, procedural generation, physical modelling and wave-based simulation
3. Infrastructure, including blockchain, uses of supercomputers and cloud computing
4. Design and fabrication, including computer-aided design, 3D printing and physical simulation
5. Creating with hardware, including wireless communication (e.g., Bluetooth, 5G, NFC), Internet of Things, LED controllers, robotics, haptics and drones
6. Immersive technology, including virtual reality (VR), augmented reality (AR), extended reality (XR) and video games
7. Financial Technology (FinTech), including payment technologies, token systems and digital tickets

As can be seen from this list, the overarching categories of innovative technologies used by Creative Informatics-funded projects have much breadth. A striking aspect is how heavily represented Machine Learning and AI, in particular, is in the Creative Informatics projects to date. Likewise, there is much breadth in the overarching category of Creating with Hardware - under which projects intersect the physical and digital realms. Our current analysis is not quantitative and does not show how many individual projects are using each technique/technology, nor does it explain why some overarching categories are so well represented within the portfolio (see the Discussion for further reflections). However, the large variety of technologies within these categories of Creating with Hardware and Machine Learning and AI indicates that these domains of technologies are currently potential hotspots for creative, data-driven work.

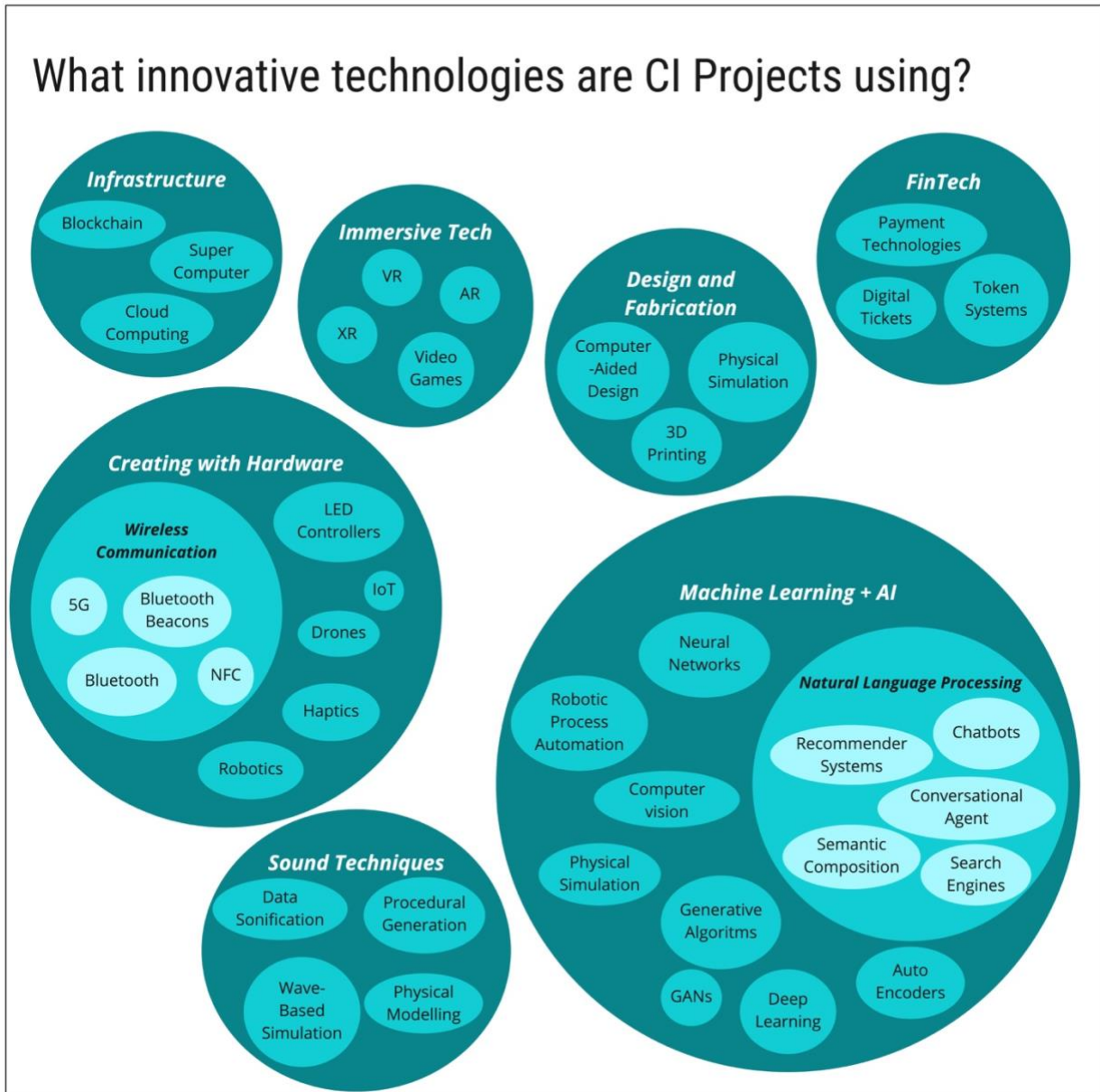


Figure 1. An affinity map showing 7 clusters of key technologies that Creative Informatics projects are engaging with, including: infrastructure; immersive technology; design and fabrication; financial technology; creating with hardware; sound techniques; and machine learning and artificial intelligence.

5.2. Data Domains

For each project, we also catalogued various kinds of data mentioned by the projects. This goes beyond specific technical data formats, instead focusing on the subject of the data (e.g. Air Quality, Employee Data, Geometric Data). We coded inductively, using the terms participants used in their applications as far as possible. After open coding, we resolved similar codes and clarified any unclear codes. We then undertook affinity mapping of these codes to identify related clusters of data domains. These clusters are represented below. As can be seen in Figure 2 below, we identified 8 clusters, which were:

1. User data, including but not limited to user generated content, personal data, listening behaviour data and payment data
2. Audience data, including customer journey data, cultural data and marketing data
3. Organisational data, including recruitment data, supply chain data, sector data, employee data and business data
4. Venue/performance data, including show production data, scene model and venue
5. Archival data, including literary excerpts, historical data, historical reconstructions and library collections
6. Spatial/physical data, including product manufacturing data, geometric data, sensory data, architectural data and physical data
7. Media data, including audio data (e.g. recorded sound and musical scales) and metadata (e.g. show control systems data, podcast data and video production data)
8. Environment/climate data, including environmental impact data, carbon management data, satellite data, emissions data, weather data and air quality data

There is much variety in the types and domains of data that Creative Informatics projects have been using and drawing on. Some of these categories of data are well established and standard for use by businesses - for example, audience data (e.g. customer journeys), user data (e.g. personal data, user generated content), and organisational data (e.g. supply chains, recruitment data). Other categories of data, however, are perhaps more unique to the Creative Industries - for example architectural and geometric data, as well as data related to musical scales and video production. The overarching category of environment/client data in the figure also provides an initial picture of how a number of Creative Informatics projects are engaging with environmental issues, interestingly, despite this not being a core, advertised Creative Informatics challenge.

What is the 'data' in Creative Informatics projects?

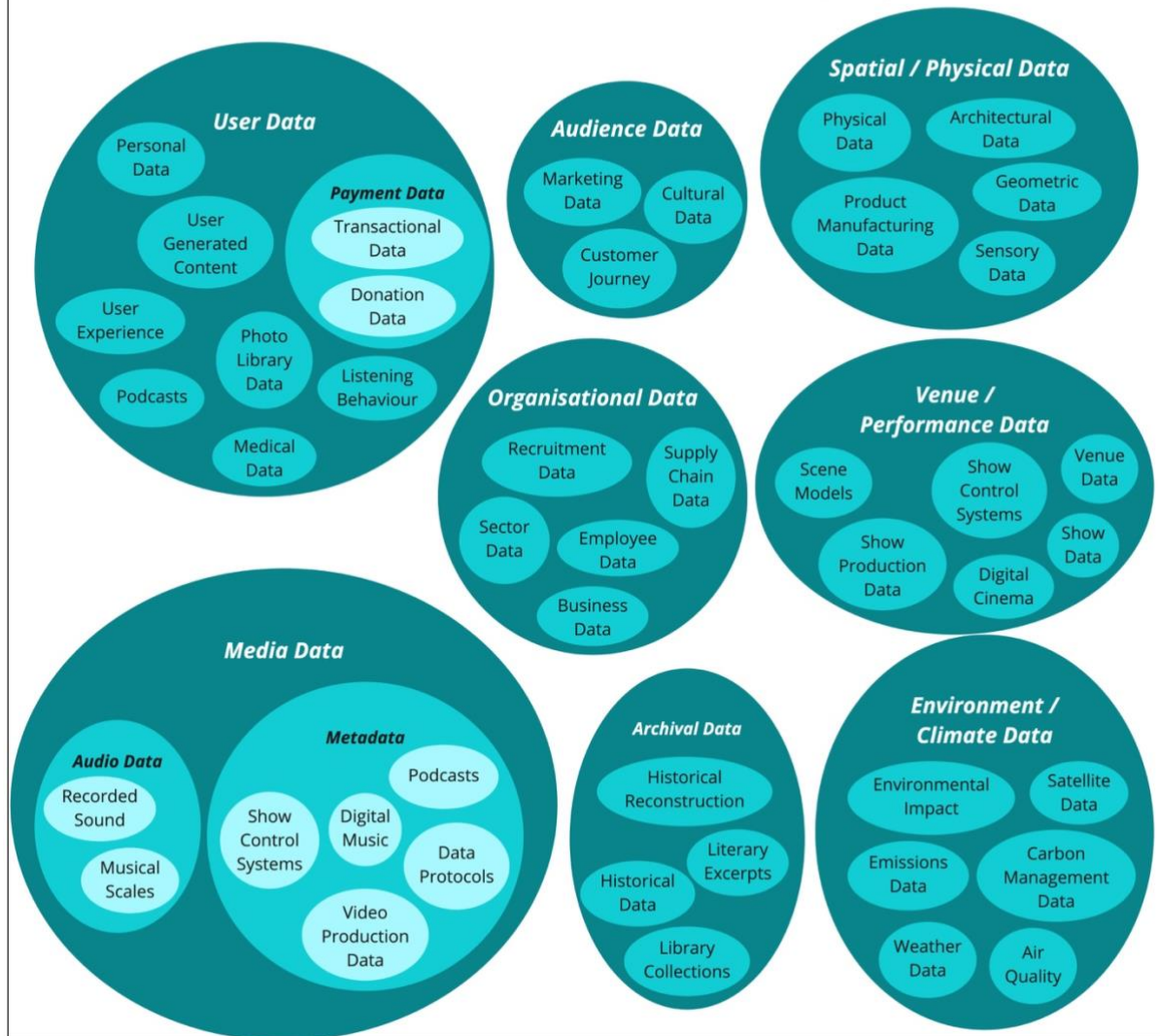


Figure 2. An affinity map showing 8 clusters of data that the Creative Informatics projects are focusing on. These include: user data; audience data; organisational data; spatial/physical data; venue/performance data; media data; archival data; and environment/climate data.

5.3. Subject Keywords

For each project we also coded keywords that describe the primary domain, focus and topic of the projects, beyond working with specific data or technologies. This was an opportunity for more open coding, and addressed, for example:

- The domain of the projects (e.g. heritage, health, education, festivals etc.)
- Particular practices or methods the projects proposed to use (e.g. image cropping, data visualisation, sound production, participatory design)
- Key challenges the projects engaged with (e.g. choice paralysis, collaboration, accessibility, sustainability)

After inductively coding for subject keywords, we resolved similar codes and clarified any unclear codes. We then undertook affinity mapping of these codes to identify related clusters and themes of technologies with a particular focus on the topic and challenges of projects. Figure 3 below shows a high-level summary of the primary challenges Creative Informatics projects address. A more detailed helicopter view, including the original codes, and which illustrate the formation of these high-level descriptions, is shown in Figure 4.

Mapping the subject keywords was far more revealing than mapping of technologies and data domains in terms of the larger goals Creative Informatics projects are attempting to achieve. Specifically, the affinity mapping revealed that the projects funded so far can be seen as addressing five overarching challenges: 1) developing new tools and interfaces; 2) supporting others' creative practice and skills; 3) addressing societal challenges; 4) exploring new data-driven techniques; 5) building data-driven economies. As is evident, these challenges are wide ranging. Some are concerned with innovating *within* the Creative Industries, for example, in terms of developing new forms of interacting with digital content or real-world experiences, or more fundamentally developing new techniques/technologies. Others are concerned with innovating *for* the Creative Industries, for example supporting upskilling in Creative Industries, or enabling other creative practitioners to experiment with data-driven innovation in easier ways. Still others are more critical and socially-focused, or aim to innovate business models, financial and economic systems. Clearly, this is just one way to characterise these projects, and only the beginning of more in-depth analyses.

What Creative Industries challenges are our projects addressing?

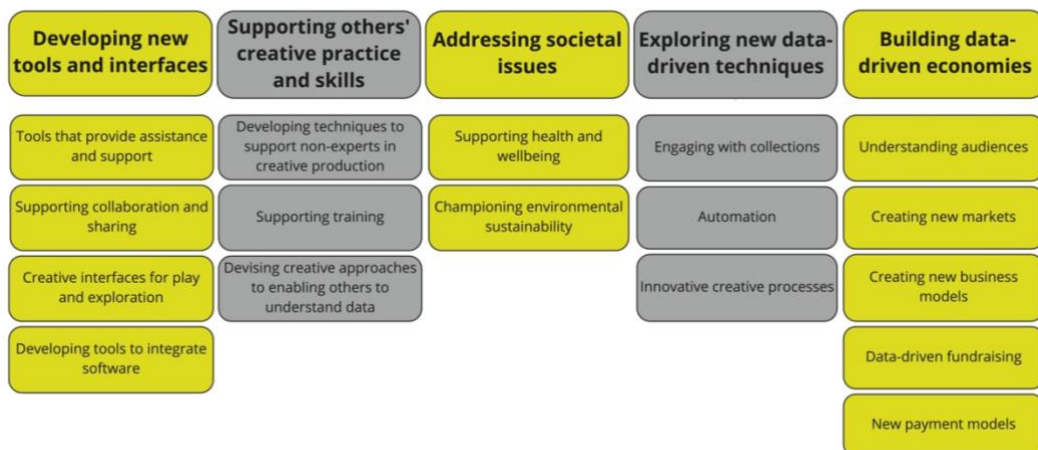


Figure 3. A figure showing the five overarching clusters of challenges that the funded Creative Informatics projects are undertaking, as revealed by the affinity mapping. Each column demonstrates one overarching challenge cluster, and the rows underneath it describe the challenges included within that cluster.

Figure 4. (next page). A more detailed, zoom-able helicopter view of the five overarching challenge clusters, including the original subject keyword codes.

What Creative Industries challenges are our projects addressing?

Key

Developing new tools and interfaces

Addressing societal issues

Supporting others' creative practice and skills

Exploring new data-driven techniques

Building data-driven economies



6. Interpreting Creative Informatics' Four Core Themes

Since the initial funding proposal, Creative Informatics has been driven by four central innovation themes, which articulate the opportunities and implications of DDI in the Creative Industries. These have been central to presentations the team has given about Creative Informatics, and they are used in part to assess the relevance and fit of applications to the programme. Applicants are explicitly asked how their proposed project relates to each of these themes, and they must relate to at least one to be considered for funding.

The four themes in full are:

1. Unlocking the Value of Hidden Archives and Data Sets
2. Revealing and Developing New Business Models
3. Developing Access and Engagement to New Audiences and Markets
4. Supporting the Development of New Modalities of Experience

Clearly these challenges may overlap, and projects may address more than one of these. Indeed, applicants often attempt to cover two or three themes in their applications. As a research team, we wanted to look critically at these challenges, and understand:

1. How are the projects we fund actually proposing to address these challenges?
2. How is data-driven innovation specifically addressing these challenges in a new way?
3. What longer term implications and trends can we surmise from these challenges, and are they the right challenges to be setting?

In each case, we have closely analysed applicants' responses to these challenges using thematic analysis. In this section, we offer some initial reflections for further research.

6.1. Unlocking the Value of Hidden Archives and Data Sets

21 of the 44 analysed projects (47%) proposed that their work is "unlocking the value of hidden archives and data sets". Based on an initial analysis of what these projects proposed to do, this theme can be broken down into three sub-categories: Creating new datasets; Finding meaning in existing datasets; and Exploring novel means of representing data.

Creating New Datasets

In response to the question of how their project proposed to "unlock the value of archives and datasets" a number of projects looked to create *new* datasets. For example, Creative Innovator [Brian Baglow](#) aimed to create a new dataset that documents the video games sector in Scotland, which could be used by all stakeholders, e.g., to explore new opportunities for the sector and for collaboration. [The Edinburgh International Festival Challenge](#) project was looking to collect 3D models of the city's cultural venues that could be shared with others, in particular to support developing staging models and animated renders for touring productions. Resident Entrepreneur [Thrifty](#) aimed to create a new database of charity shop donation items to be used to reflect on charity shop practices, as well as to find new opportunities for selling charity shop items online. As these examples demonstrate, a number of the Creative

Informatics projects have explored datasets that are shareable amongst other creative partners, or useful for multiple purposes.

Finding Meaning in Existing Datasets

A number of projects have also explored how existing datasets can be used in new ways. For example, [Russell Henderson's CoCreator](#) project looked to develop an ontology of existing film shot data, to help inform an approach to guide novices through filming. Resident Entrepreneur [BiaScan](#) proposed to research how informative datasets including, e.g., marketing data and job adverts, can be in terms of revealing what language markers that can indicate hidden/implicit bias. Another way in which some of the projects have been approaching finding meaning in existing datasets, has been by combining datasets to reveal new insights. For example, Resident Entrepreneur [One Hundred Flowers](#) proposed to combine datasets related to market data, historical data and financial data, to devise new ways of evaluating the potential of a business.

Exploring New means of Data Representation

A variety of the funded projects explored means of representing data in new, more informative or more creative ways. [Historic Environment Scotland](#) sought to present their archival, historical data to historic site visitors drawing on the modality of traditional tourist telescopes. Resident Entrepreneur [Martin Disley](#) synthesised a large digitised cultural image collection using novel Generative Adversarial Network (GAN) techniques in order to open up artistic modes of engagement with existing cultural datasets. There seems to be much novelty in the ways in which creative practitioners and organisations are exploring data representation, and we feel this is a domain that particularly warrants more empirical exploration, and one that could lead to academically rich insights.

6.2. Revealing and Developing New Business Models

26 of the 44 projects (59%) analysed so far have claimed to explore new business models for the Creative Industries in some way. Initial analyses of application responses reveal a number of common aspirations for how projects will innovate upon existing business models.

New Ways to Collaborate

Several projects looked to leverage DDI to find new ways to support collaboration, with implications for their business model. New and better ways to share and integrate data, especially between the many independent and freelance individuals and organisations in the sector is anticipated to create new ways of working, improve knowledge exchange, or demonstrate the value of creative practice in other sectors. For example, [Alex Durussel-Baker](#) proposed to explore how creative practice can be used to communicate and translate clinical information around management of diabetes.

Supporting more remote collaboration, especially where previously working remotely would have been challenging, creates opportunities to connect with new audiences and share services more broadly. [Applied Arts Scotland](#) proposed to investigate how haptic technologies could support remote teaching and collaboration of craft techniques, as a way to amplify and build online audiences for their practice.

Finally, some applications clearly position their projects in intermediary roles: facilitating better integration between clients (e.g. [High Tide](#), [Chris Harrison](#)), or providing a platform or template for others to create and collaborate. It may be interesting to explore the extent to which digital

approaches to collaboration truly differ from collective endeavours in physical spaces or clusters.

Distribution, Access and Markets

Projects described several new business models based upon being able to access new markets or engage audiences in new ways. New business models were proposed to support both developing new contexts to engage with an audience, and making applicants' work more widely accessible. DDI in particular also offers opportunities to undertake and distribute work at a greater scale and in a more replicable fashion. One particularly innovative model is presented by independent print magazine [Boom Saloon](#), who proposed a 'social distribution' model of their publication, where supporters in their community take on a small-scale distribution role, and are rewarded for doing so.

Shared Benefits

It is also anticipated that DDI might offer new ways to better share and distribute the benefits and value generated by creative economies and businesses with the communities that sustain them. Projects such as [Tentop](#), [Edinburgh Tool Library](#) and [Hidden Trax](#) looked to use data to support circular economy models, or to track and reward participation in vibrant communities over the longer term. Here, data-driven technologies may be used both to identify and distribute value and ownership within the Creative Industries.

More Efficient Use of Resources

Perhaps unsurprisingly, some projects described new business models predicated on a more efficient use of their resources. In some cases this was simply an opportunity to scale up existing operations, reallocate staff (e.g. [The List](#)), integrate tools more efficiently, or to identify and minimise waste. More specifically, projects such as [Edinburgh Tool Library](#) outlined intermediary roles where they are able to identify and match shared needs and opportunities.

New Revenue Streams

New business models were also articulated through the development of new revenue streams. For several projects this reflected opportunities to diversify income streams for artists (for example through teaching creative practice, as well as selling their art). Others identified new markets, or new contexts in which to transact with audiences (e.g. [Contactless Studios](#)). [High Tide](#), a creative production company working in film and video, sought to formalise and commercialise an existing part of their service to clients that they currently are unable to charge for. Others such as [Scottie](#) were responding to the closure of venues during lockdown, and sought to explore new monetisation strategies and pricing around digital performance. Finally, some of these new revenue streams were positioned as being a means for audiences to more directly fund and support artists and their creative practice.

New Services and Products

Finally, new business models were envisaged through the development of wholly new products, services and audience experiences. In one case, these were services based on learning about data ([Sian Bevan](#)); in another these were products directly generated through a customer's personal data ([Gifted](#)). In the longer term, we might look to understand how much the development of new data-driven products and services fundamentally changes a business model, or just augments it.

6.3. Developing Access to and Engagement to New Audiences and Markets

31 of 44 projects (70%) identified as developing access and engagement with new audiences and markets. We noted four primary approaches to achieve this underpinned by data-driven innovation.

Digital Distribution and Audiences

First, several projects aimed to expand or pivot to serving online customers and audiences, and a wider, potentially global market. This was especially the case in the context of the COVID-19 pandemic, which forced many businesses to close or restrict physical premises and venues. Funded projects described approaches to identify online audiences, distribute creative work in new ways, and develop new ways to pay for and support this work.

Remote Collaboration and Engagement

In addition, several projects proposed to explore how being able to collaborate and engage with other creative practices and industries remotely can enable them to serve new audiences and markets. For example, supporting remote collaboration on craft projects could support exchange of knowledge and expertise, and allow makers to better address needs and interests of remote audiences and students ([Applied Arts Scotland](#)).

Furthermore, physical venues and spaces such as the [City of Literature Trust](#) (together with [Bright White](#)) are exploring new ways to serve remote audiences who cannot, or would not usually attend shows or exhibitions in person, but may be encouraged to do so online. In particular, projects identified that by developing digital experiences for in-person attendees, these could subsequently be adapted to address a wider audience online, and vice-versa.

Improved Creative Products and Services leading to New Audiences

Several projects anticipated that by improving creative products and services through data-driven approaches, they would be able to engage and attract new audiences and markets. For some this was about making creative work more accessible and available; for example, [Chris Harrison](#), a lighting designer, proposed to develop a hardware platform which will make it easier to integrate his work in different contexts, for different clients needs. Others such as [ploterre](#) recognised that by being able to scale their practice, they could serve more numerous, smaller clients. For others, they saw themselves producing wholly new kinds of creative work and practice through data-driven tools, and this in itself would expand their audience and market (e.g., [Sarah Calmus](#), [Michael Begg](#)), or help them better address particular audiences (e.g. [Chris Dooks](#), designing artistic services for sufferers of chronic fatigue).

Marketing and Identifying New Audiences

Finally, several projects explicitly sought to use and develop digital tools to improve their approaches to marketing ([One Hundred Flowers](#), [Physical Audio](#)). In particular they sought to better identify the needs of their audiences and clients, and make better use of customer and audience data ([Scottie](#)). Some projects saw opportunities to more clearly identify and serve niche markets and audiences; others explicitly sought to market and tailor their services more intelligently for a broad audience.

6.4. Supporting the Development of New Modalities of Experience

30 of 44 (68%) projects identified themselves with developing new modalities of experience. We take modalities of experience to mean new ways of experiencing the digital and physical worlds, through the support of data-driven technology. Our analysis revealed that projects' responses to the question of how they proposed to engage with 'developing new modalities of experience' varied widely; they proposed to do this by: developing artistic modes of experiencing data; developing immersive and multi-modal experiences; exploring intersections between digital and physical experiences; creating digital accompaniments to in-person experiences; designing "from" and "with" data; and using data and technology to (new way of experiencing) support/augment creative workflows.

Developing Artistic Modes of Experiencing Data

Some projects have proposed to develop artistic modes of experiencing data for audiences. They have done so in various ways, from using Generative Adversarial Networks as a means of synthesising and changing the mode of experiencing digitised cultural collections ([Martin Disley](#)) to exploring how environmental data can be made musically meaningful - for example, how it can be related to timbre, key and tempo ([Michael Begg](#)). A strength of Creative Informatics-funded work that is thus quickly emerging, is the exploration of how data can be presented to a diversity of audiences through imaginative modalities and data-driven processes.

Developing Immersive and Multi-modal Experiences

A substantial subset of the projects proposing to "develop new modalities of experience" have focused on developing immersive and multi-modal experiences. These have ranged from using immersive interfaces with sound as a sensory channel to explore cultural content, to creating toolkits for multi-sensory cinema experiences, drawing on Internet of Things technologies ([New Media Scotland](#) with [Ray Interactive](#)). Sound has been particularly well represented in the projects funded so far - from using sound to engage people with cultural content ([City of Literature Trust](#) with [Bright White](#)), and communicate data ([Michael Begg](#)), to engaging people with music through embodiment ([Refract Music](#)). The multi-sensory and multi-modal nature of the experiences that have been explored seem to have much potential for leading to rich empirical directions, for example in the domains of Human-Computer Interaction and Interactive Media Experiences.

Exploring intersections between digital and physical experiences

Far from being wholly digital, a number of the projects have explored intersections between digital and physical experiences. Projects have explored creating digital equivalents to physical experiences - for example, [Stemz](#) - a physical Maker toy geared at children - has explored how to make a physics-based digital simulation for Stemz in order to extend the experience it offers. In contrast, others have explored how to provide a physical means of experiencing the digital, or intangible - for example, [Refract Music](#) has explored how embodied, physically rooted interfaces can provide an accessible and tangible means of engaging with music concepts. From these projects, it is evident that within the Creative Industries there is ample opportunity for the physical and digital to go hand in hand, supplementing each other, and opening up new ways of developing compelling experiences.

Creating digital accompaniments to in-person experiences

A number of projects have also proposed to develop digital accompaniments to in-person experiences. [Jupiter Artland](#), an outdoor contemporary art gallery and sculpture park, used their Creative Informatics Challenge project to explore a more guided visitor experience, based on a conversational agent that does not demand an audience's visual attention (together with [InChat](#)). In another project, [Stageport](#) has been developing a mobile application comprising an interactive digital archive from a show production process that the company can share with their audience to complement a live performance before, during and after. These forms of projects are exploring how data and technology can be used not to replace, but rather to enhance and augment established, in-person experiences. A question for the COVID-19 crisis, is whether possible benefit of these forms of digital accompaniment may also facilitate a shift to remote accessibility.

Designing “from” and “with” data

Beyond using data-driven technologies as a “material” for design, some projects have also used data as a resource to design “from” and “with”⁵. In these projects, data can be seen not just as the enabler of the experience, but also perhaps as a design partner, or a source of design inspiration - from designing 3D objects from and with personal data ([Gifted](#)), to using data as a parameter in generative graphic design ([ploterre](#), formerly known as graphicmatics).

Using data and technology to support/augment creative workflows

A particularly fruitful application area within Creative Informatics projects thus far has been developing new ways for *other* creative practitioners to engage with data and technology. A number of the projects have aimed to make new data-driven techniques and technologies, that are usually reserved for experts, available for other creative practitioners to experiment with and use in their work. An example has been developing an easy-to-use interface to make the process of sound and soundscape generation through procedural audio and physical modelling available to independent producers ([Black Goblin](#)). Another project has focused on building a platform for digital monetisation and publishing for small arts organisations and venues ([Scottie](#)). The variety of projects focused on supporting and augmenting others' creative workflows, positively attests to how the use of data and technology by one creative sector, can support innovation in others.

⁵ Speed, C., & Oberlander, J. (2016). Designing from, with and by Data: Introducing the ablative framework. In Proceedings of the International Design Research Society Conference.

7. How is DDI envisaged to generate economic value in Creative Cultural Industries?

When applying for funding, Creative Informatics projects are asked to describe the ‘economic benefits’ of their project. There are clear expectations of financial sustainability for the majority of the projects that Creative Informatics funds and this expectation is reflected in applicant’s responses. These responses articulate new products, services, processes and business models that are anticipated to result from their projects and bring an economic benefit. It is useful to understand the various ways applicants envision these benefits, but they also allow us to ask more deeply - in what ways is Data-Driven Innovation (DDI) expected to generate economic value? How is this anticipated to work, and what are the potential implications of DDI in the Creative Industries as a driver of economic value?

Applicants’ responses are necessarily optimistic and speculative when it comes to describing how funding to support DDI will benefit their businesses and the broader sector economically. However, there are a number of recurring ambitions, proposals and assumptions from participants that mark out territory for further critical inquiry. We summarise the logic of how data-driven projects are envisioned to generate economic benefits below.

DDI can be used to gather and share new and better data on Creative Industries that can inform better business models

As mentioned in 6.1 several projects are focused on gathering and sharing better data about customers, audiences, clients, events, or a whole creative sector. In particular, sectors with many freelancers and independent companies, such as the gaming and theatre sector (see [Brian Baglow](#)), are understood to be lacking data on, for example, the make-up of the sector, funding and business opportunities, and historical practice and insights - all of which could support strategic decision making, and opportunities to collaborate and share resources. For example, how could shared data and experiences of theatre makers, producers, venues and festivals be brought together to inform decisions about how, when and where to tour a new show ([Centrline](#))? In these cases, DDI is proposed primarily as a way to make such data widely available, and easily updated and queried.

DDI can facilitate new shared revenue streams

Beyond a more general effort to better understand specific creative sectors or practices, some projects turn to data-driven approaches as an opportunity to develop alternative revenue and profit-sharing models. New digital tools or platforms are envisaged to better record, identify and manage the contribution or rights of different actors (creators, customers, intermediaries). For example, in the context of music production, the credit for particular work can be more definitively registered, at the point of production, to ensure that subsequent royalty payments are shared appropriately ([Delic](#)). Other projects based around new creative marketplaces propose means to reward loyalty and investment of consumers and creators who help grow and sustain the marketplace, where data around their use of a platform could inform their reward (e.g., [Tentop](#), [Hidden Trax](#)).

DDI can support wholly new kinds of valuable creative products and services

For many Creative Informatics projects, DDI is integral to developing new creative practices, products and services. For example, by collaborating with generative machine learning algorithms, artist [Martin Disley](#) was able to reimagine the National Library of Scotland’s map

collection and explore a new service for museum visitors. [Gifted](#) uses a generative, data-driven approach as a means to valuably personalise creative products for consumers. Several other projects develop approaches to digitally modelling and virtually recreating traditional creative practices, such as sound recording, or developing virtual environments of performance venues to support staging and lighting design remotely and ahead of time. Such approaches generate and require access to valuable new digital assets, such as 3D scans of a building interior ([Stageport](#)), or a sound library ([Black Goblin](#)). The production and management of these assets in itself may be part of new business models for the Creative Industries. However, initially, several of these projects have focused their efforts on integrating new digital approaches within existing creative workflows. For example, by reducing the needs and costs of accessing and using valuable physical resources (such as access to a performance venue, or recording studio) the costs and risks of a production can be reduced.

DDI can make creative practices and businesses more efficient

A familiar ambition of data-driven approaches is to make creative practices and businesses more efficient. Forms of automation, for example automatically cropping images for different publications ([The List](#)), is envisaged to alleviate labour intensive practices, and allow greater focus on 'higher value' tasks and creative thinking. Other projects have identified opportunities to make the financial or administrative aspects of Creative Industries more efficient - including efficiencies in accessing important information and creative resources, managing payments and licencing, and engaging with audiences and clients. DDI in these contexts is often invoked to automate, collate, present opportunities, or manage a workflow more consistently.

DDI depends upon formalising creative practices and services to support commercialisation

Looking beyond approaches to more efficient practices, several funded projects entail efforts to formalise once bespoke, and flexible creative practices and services into specific digital products and toolkits. Various, this can allow for scaling, reproduction, modularity, more rapid iteration and easier integration with other products and services - all of which support individual creatives and small companies in serving a greater range of clients and commercialising their practice. For example, an approach taken in one project, may be easily extracted and applied to another context or client ([High Tide](#)); templates or models of a service can support clearer engagement and negotiation with clients around what they need or value, and allow further turns of iteration and feedback ([ploterre](#), formerly known as graphicmatics); specific tools or methods themselves could be developed into paid-for services that others can use or apply themselves ([Russell Henderson's CoCreator](#)); or it may be easier to combine and manipulate different elements of a production together (e.g. sound and lighting). Economically, all of these approaches support expanding or growing the market(s) that a creative company can serve, by taking on more projects, being better able to communicate and respond to specific client's needs. For example, several projects described how formalising their approach would allow them to work with smaller clients and serve a market they may not have been able to previously.

Such formalisation is common in developing more efficient and consistent business practices for broader markets. What is notable here however is the implications of formalising and committing to specific repeatable processes, as part of a creative practice, which may otherwise be more flexible, unpredictable and holistic. What are the limits to the extent to which creative practice and processes can be categorised, modularised and extracted from their original context? What skills and knowledge will reside only within an individual creator or technician, and what can be more broadly 'democratised' or made available for wider

audiences to undertake themselves, following templates or supported by automation and digital workflows (e.g. [PicoJar](#), [CoCreator](#))? And over time, how will data about these creative processes become valuable in and of itself?

DDI funding begets further economic investment

Finally, and perhaps unsurprisingly, several applicants noted the economic benefits of funding in and of itself. Funding provided time to hone and formalise one's practice, and realise how it could be developed into a commercial service, or augmented through new digital tools. Funding of any kind can (and has) attracted others to invest, and there can be a particular kudos to funding centred on digital innovation, which supports the impression of a modern and future-focused creative business.

8. Discussion and Future Work

This Catalogue is an opportunity to reflect critically on the kind of work Creative Informatics has supported and is producing, and more broadly to identify important trends and implications for data-driven innovation in the Creative Industries. To this end we offer some broader reflections on the nature of the projects funded so far, and some outstanding questions for further research and follow-up as the Creative Informatics cluster progresses.

8.1. Features of the Creative Informatics Catalogue

Firstly, it's notable that many of the projects and examples we have reported offer familiar stories and aspirations of digital transformation and innovation as in many other contexts. This may not be surprising, as applicants likely reflect and engage with common understandings of the transformational power of digital technologies. Furthermore, given the impact of the COVID-19 pandemic, like many other businesses in the past 12 months, numerous projects are engaged with how to use a variety of digital tools to effectively deliver creative products, services and experiences remotely.

Nonetheless, it's striking that Creative Informatics projects address a 'full-stack' of digital technologies and multiple incarnations of the concept of 'data'. As our affinity mapping analysis has demonstrated, project applications range from building fundamental digital infrastructure, and managing databases, including novel software and hardware, through to designing front-end user experiences and applications. The potential scope of technological uses and applications in the Creative Industries remains vast. Similarly, we see new technology applied throughout all aspects of creative businesses: from transforming fundamental creative practices and mediums, through to informing decision making, marketing, distribution and audience engagement. Furthermore, we see many projects closely aligned with a growth agenda (explicitly encouraged through the application process), where digital technologies are envisioned to allow creative practices and businesses to scale and be commercialised in new ways.

However, as the cluster develops, it's important to address what may be fundamentally distinct about digital innovation in the Creative Industries in comparison to other sectors. Three potential points of distinction stand out. First, as sectors that are predominantly made up of freelancers and small businesses and tend to work closely together on a wide variety of projects, there are clear needs for tools and services that support better collaboration across the Creative Industries; many of our funded projects seek to address the challenges of collaboration in one way or another, and especially remotely. Shared records, databases, digital tools and studios all take on an additional value in the Creative Industries. Second, beyond being well-positioned to adapt and appropriate innovative technologies and data-driven methods, DDI work in the Creative Industries also has the potential to reimagine them completely. As our analysis has demonstrated, the Creative Industries are uniquely positioned to reimagine novel technologies for different means than traditionally envisioned, devise new data-driven approaches that can feed into cutting edge developments in engineering and computing, as well as be more exploratory, societally-aware and critical in terms of how technologies and data are used than other sectors. Third, creative practices are often unstructured, hard to define, and can rely on a great deal of individual skill and experience. This is at odds with the logical, formalised and repeatable processes that digital technologies

typically rely upon. While this is a familiar tension between human and machine ways of knowing, it can be especially acute in the context of art and creative practice. Creative Informatics aims to address this in part through various digital skills and literacy programs (e.g. [Creative Bridge](#); [Raise Your Game](#)). However, we should closely follow how creative businesses and practitioners can harness the opportunities of digital technologies, without fundamentally undermining the unique and situated value of their creativity and craft.

8.2. Key reflections on trends represented in the Catalogue

Having highlighted the diversity of the projects represented in the Creative Informatics Catalogue, in this section we highlight three key trends we have observed within the Catalogue, and present our initial reflections on what these may mean for the concept of creative clusters, and for the nature of creative innovation more broadly.

Creative Informatics projects address challenges both within and beyond the Creative Industries

It is notable that the catalogued Creative Informatics projects address both challenges within the Creative Industries (e.g. sharing data with other creatives, enabling access to data-driven techniques) and beyond the Creative Industries (e.g. developing creative, data-driven products and services to engage wide audiences). Specifically, an unexpected subset of the projects have dealt with designing products and services to help other creative sectors to engage with innovative data-driven techniques and technologies. This has been for example, by making state-of-the-art audio generation techniques or computer-generated models available to other creatives who might not have the skills to develop them themselves. This is a positive finding for the very concept of a creative cluster, where a core aim is to enable creative sectors to support each other and stimulate the growth of others.

A substantial subset of Creative Informatics projects have a societal focus

A positive finding from our analysis is that a substantial subset of the Creative Informatics projects have in some way engaged with societal and social issues. As demonstrated in the affinity mapping of the subject keywords, projects have sought to address issues, e.g., related to accessibility, health and well-being, workplace bias and environmental sustainability. Creative Informatics funding applications ask applicants to consider whether their projects have environmental, social and cultural value in addition to economic value, but do not necessitate that projects address societal issues as a prerequisite to receiving funding. Thus, that such a variety of socially engaged work is represented in the Catalogue is a compelling finding. This could be partially correlated with the fact that (at least implicitly) the Creative Industries tend to be critical and societally engaged in nature. It calls to question whether an increase of data-driven work within the Creative Industries might lead to an increase in critical and socially-conscious data-driven techniques and technologies, more generally.

Some categories of technologies appear more represented than others

Our analysis identified two broad categories of technology that are so far seemingly much more represented within the Creative Informatics Catalogue than others, given the variety of child codes within them: Machine Learning and AI, and Creating with Hardware. A question this raises, is whether these categories are particularly suited to creative endeavours? For example, as many Creative Industries depend upon physical engagement and practice, new forms of hardware (e.g., Internet of Things, Haptics, LED lights, Drones) may particularly support these forms of work. At a more critical level, however, another question is whether these categories are more represented because Creative Informatics is more interested in

funding them (either explicitly or implicitly)? It could be that Creative Informatics panellists feel that some domains of DDI are more innovative, or potentially impactful (economically or otherwise) than others; this is a point we as a team endeavour to remain critical and reflective about throughout the funding process.

8.3. Challenges of Doing Novel Research on Challenge-led Industry Projects

The Creative Informatics programme began with the ambition to promote DDI in the Creative Industries and in the Edinburgh and South East Scotland region, in response to the AHRC's aims of promoting growth in the digital and creative economies. Interestingly, despite being an academically-hosted programme, the research aims were deliberately open ended and responsive to project participants, rather than pursuing predetermined academic work packages. There has always been a need therefore to balance aims to undertake novel research, meaningfully engage with creative communities, and spur innovation⁶. In this context, the Catalogue offers broad reflections on the Creative Informatics cluster, but also surfaces new empirically rich research questions about the intersections of creativity, innovation and the economy. In this respect, it has been foundational for further, in-depth research on specific projects, domains and challenges related to Creative Informatics.

8.4. Reflections on the Methodology

We developed our methodological approach for the Catalogue given the rich project data that we had access to through the funding structure of the Creative Informatics programme. As a starting point, we chose to analyse the funded projects' original applications to the funding strands. Here, applicants are required to describe the forms of technology and data they are developing in their work, discuss how the work fits into the core Creative Informatics team, and reflect on the values driving their work - making them a descriptive data source for our aims. Analysing these applications offered a pragmatic starting point to map out a very broad range of projects. Being rooted in the applications themselves, the Catalogue has 100% coverage of the funded projects - which would likely not be the case if, for example, we sent out tailored surveys to each funded project. This approach therefore provides a thorough descriptive overview of the forms of research and development taking place on Creative Informatics.

However, there are challenges with and limitations to this data set. The first is the context in which the projects provide the data: by virtue of the context being funding applications, the applicants' responses to the questions may at times be overly optimistic in terms of what can be achieved, or how innovative or impactful a particular project can be; therefore, they must be read and interpreted with a critical eye. Second, our current analyses are based on what applicants promised or hoped to achieve, and not (yet) what was done within the remit and timeframe of the funding; our analysis also does not include information about pivots that the

⁶ Lechelt, S., Elsdon, C., Helgason, I., Panneels, I., Smyth, M., Speed, C., & Terras, M. (2019, November). How Can We Balance Research, Participation and Innovation as HCI Researchers?. In *Proceedings of the Halfway to the Future Symposium 2019* (pp. 1-4).

funded projects may have made. In our next phases of research, we plan to account for this by integrating interim and final project reports in our analysis - where the projects reflect on whether, and to what extent, they have met their initial funding goals. A third challenge with our dataset is that it is gathered from a vastly heterogeneous group of individuals, who have a large variety of professional backgrounds. For example, some applicants who might not have a background in working with data and technology, may underspecify how their project relates to DDI, which we need to be mindful of when coding and analysing the data.

While adding more quantitative measures (e.g. in terms of the numbers of projects working with a particular form of technology or a particular subject keyword), would have been straightforward to do, due to the diversity of projects coupled with the small sample size we did not feel adding quantitative measures would be informative at this stage. However, we feel that there is much richness in our chosen approach of providing qualitative and descriptive interpretations, and that our method thus far is particularly good at highlighting the diversity of compelling R&D directions and questions about the nature of innovation for/with the Creative Industries. In this respect, we hope sharing our approach may be helpful to other researchers as they look to follow and reflect on diverse sets of industry projects.

8.5. Outstanding Research Questions for Creative Informatics

Building on these reflections, we offer some more specific research questions that will guide our own and we hope other's future research in Creative Informatics.

What does new technology actually enable?

While the projects funded so far entail a very broad range of technological and data-driven approaches, it is often unclear *exactly* what a technology will do or enable or indeed, the value any new technology is perceived to possess. For example, AI is often applied to support decision making; virtual environments can support remote working; FinTech can facilitate new ways to pay for or support creative practice. Looking beyond buzzwords and self-fulfilling digital prophecies requires close attention to where and how technology is applied in creative enterprises, as well as the human labour required to make technology work.

What truly new business models are enabled by data-driven innovation in the Creative Industries?

Our applicants clearly articulate how digital technologies will change their current business models. However, on initial inspection, technology serves to extend, develop or pivot existing practices, rather than producing truly new business models for a creative business. In particular, we should look at how data itself, and the production and management of new digital resources and assets can enable new business models and intermediaries in the Creative Industries. In addition to digital literacies, this may require new entrepreneurial skills (a focus of the *Creative Bridge* programme run by Codebase). Likewise, while we identified many envisaged economic benefits of new technologies, we need to interrogate further the related costs and effectiveness of these economic value propositions as Creative Informatics' projects evolve.

How are different categories of data in the Creative Industries legally and commercially defined and understood?

The 'data' in Creative Informatics projects is clearly diverse. It ranges from data *as an input* to, and reflection on, creative practice, through to data *about* audiences, venues, and creative businesses and institutions themselves. This also means that these projects take place in the

intersection of complex and rapidly developing legal frameworks, frameworks that come with their own conceptualisations of data, creativity and authorship that may or may not match the way these terms are understood in creative practises. The way in which law bestows different modes of control over different types of data in turn impacts on proposed business model or value propositions. When a software company trains an AI on photos from the 19th century, taken from the anthropological collection of a public archive, and the AI then allows contemporary game designers to create immersive experiences where users can create short stories within a virtual universe, a complex set of legal and ethical questions are raised. These range from the personality and dignity rights of those depicted in the photos to the intellectual property regime for the images, from the question of (co)authorship and with that possible co-ownership of the resulting digital objects to data protection questions if data from the user experience is used to monetise in-experience advertising.

The way in which intellectual property and data protection can help or hinder innovation is of course a long-standing debate. However, experimental uses of data in the creative sector create new and unique challenges that are not a mere extension of the issues other sectors are facing. Research questions include how different communities conceptualise and understand their “stake” in the process and their ownership claims over the outcomes. How do creators or any co-creators among their customers align conceptions of IP law with their practices, and how can IP law be adjusted to allow them to reap just rewards for their work?

Data Protection law, and even more so the envisaged new EU regulation on AI, distinguishes “high risk” uses of data from those uses that require less constraint and control, requiring often complex risk assessments. Currently, individual creators or SMGs are lacking the expertise, tools and data to carry out such analysis, creating considerable uncertainty and legal risks for them. Can we develop better methodologies to help with this process?

Finally, the arts also challenge and critique social practices and legal regimes that support established power structures. When Mediacollecive Bitnik send its AI shopper on the darknet to buy through a random process goods, they knew, and anticipated, that some of these goods would be illegal. Nonetheless, the Viennese prosecutor’s office permitted the exhibition to go ahead, as the constitutionally guaranteed freedom of art in this case allowed even minor infractions of the criminal law. This too creates new research questions in the intersection between creative informatics and the law: how can data driven creative practices also be used to critique, challenge and probe the law?

What are the implications and limits of formalising creative practice for digital applications and platforms?

A key trend noted in the Catalogue is that of creative practice being formalised into legible, repeatable and communicable processes that can be more widely understood, utilised and scaled up, by people and machines. There are of course fundamental questions about how well, and under what conditions various forms of creative work can be made to fit specific parameters, while retaining the flexible and emergent nature of creativity. However, more broadly, it’s important to consider what happens as creative practice becomes visible and knowable to digital intermediaries. There is a growing literature on how digital platforms generate economic value and become powerful by accumulating and extracting the key properties and features of an existing industry, and repurposing these towards new products and services. For example, Netflix is able to commission niche and specific shows, based on data about their audiences’ viewing habits; JustEat could use data on eating habits to identify gaps in local food scenes for new pop-up restaurants. Some Creative Informatics projects may

be well positioned to take advantage of their positions as digital intermediaries in this way, while others may be exploited or undermined through such practices. It's important therefore to look critically at how data, tools and platforms based on abstracting and formalising creative practice, support rather than exploit the industries on which they are based.

What are the broader implications for the future of labour in the Creative Industries?

Finally, implicit across numerous Creative Informatics projects are changes to the nature of work in the Creative Industries. There are familiar fears about automation, which can alleviate repetitive tasks but could also see jobs lost. We should examine how labour 'freed up' by automation is redeployed in practice, and the economic and social implications involved. On the other hand, successful companies in our cohorts are growing, gaining investment and recruiting new members of staff. We should look closely at the nature of these roles, and what they might indicate in terms of valuable skills for a more data-driven future in the Creative Industries. In particular, we should be attentive to the most necessary and valuable digital skills that creatives require or benefit from. In addition, as new technologies are introduced, they clearly have the potential to disrupt the power and independence of some roles; for example, a museum curator in the future may be expected to work with a game designer and data scientist who are able to identify the most and least engaging aspects of a digital exhibition. While there are clearly empowering possibilities in such a scenario, we should critically examine the emerging power relations, and equity in such contexts.

8.6. Next Steps and Opportunities for Collaboration

Cataloguing is an ongoing process for Creative Informatics, as projects are completed, and new applicants are funded. In our work to date, we have developed a methodological approach for the catalogue, and identified rich terrain for further critical research into what it means to do data-driven innovation in the Creative Industries. We will continue to catalogue new funded projects, as well as examining the actual outputs and trajectories of the projects discussed here. This step is critical, as while this research gives a broad view of what Creative Informatics looks like, most of our data here is based on what people say they will do, rather than the gritty details of how that works in practice. Incorporating projects' interim and final reports into the catalogue as they complete their work will go some way to address this, however we expect to pursue more detailed case studies of specific projects around themes outlined in this report.

As this work continues, we actively invite and encourage academic and industry colleagues to engage with us on this work around opportunities to collaborate. Creative Informatics has funded a very broad range of projects, across multiple subject areas, opening up many avenues and opportunities for collaboration with the Creative Industries but also with other academics - both in terms of supporting creative projects themselves, but also for recording and analysing what they mean for the Creative Industries. Our ambition is that this evolving Catalogue provides a strong basis from which to do so.

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Appendix A: Links to the Mentioned Funded Projects

In this appendix, we include a list of the links to all of the Creative Informatics-funded projects that have been mentioned in this report, which have all been hyperlinked in-text. Please note that not all of the projects that have been funded by Creative Informatics so far have been specifically mentioned in this report. To see overviews of other projects we have funded, please visit the Creative Informatics community webpage as well as the Creative Informatics news webpage:

Creative Informatics Community webpage: <https://creativeinformatics.org/community/>
Creative Informatics News webpage: <https://creativeinformatics.org/news/>

Links to the mentioned projects:

- Alex Durussel-Baker: <https://creativeinformatics.org/showcase/creative-edinburghs-connected-innovators>
- Applied Arts Scotland: <https://creativeinformatics.org/showcase/creative-edinburghs-connected-innovators>
- BiaScan: <https://creativeinformatics.org/showcase/meet-our-resident-entrepreneurs>
- Black Goblin: <https://creativeinformatics.org/participant/black-goblin-audio>
- Boom Saloon: <https://creativeinformatics.org/participant/boom-saloon>
- Brian Baglow: <https://creativeinformatics.org/participant/brian-baglow>
- Bright White: <https://creativeinformatics.org/participant/bright-white>
- Centrline: <https://creativeinformatics.org/participant/centrline>
- Chris Dooks: <https://creativeinformatics.org/showcase/creative-edinburghs-connected-innovators>
- Chris Harrison: <https://creativeinformatics.org/showcase/creative-edinburghs-connected-innovators>
- City of Literature Trust: <https://creativeinformatics.org/challenge/edinburgh-unesco-city-literature-trust>
- CoCreator / Russell Henderson: <https://creativeinformatics.org/showcase/give-it-up-for-our-round-2-resident-entrepreneurs>
- Contactless Studios: <https://creativeinformatics.org/participant/contactless-studios>
- Delic: <https://creativeinformatics.org/showcase/meet-our-resident-entrepreneurs>
- Edinburgh International Festival: <https://creativeinformatics.org/challenge/edinburgh-international-festival/>
- Edinburgh Tool Library: <https://creativeinformatics.org/participant/the-edinburgh-tool-library>
- Gifted / Jason Morenikeji: <https://creativeinformatics.org/participant/jason-morenikeji>

- Hidden Trax: <https://creativeinformatics.org/participant/hidden-trax>
- High Tide: <https://creativeinformatics.org/participant/high-tide>
- Historic Environment Scotland: <https://creativeinformatics.org/challenge/historic-environment-scotland>
- InChat: <https://creativeinformatics.org/participant/inchat>
- Jupiter Artland: <https://creativeinformatics.org/challenge/jupiter-artland>
- The List: <https://creativeinformatics.org/challenge/the-list>
- Martin Disley: <https://creativeinformatics.org/participant/martin-disley>
- Michael Begg: <https://creativeinformatics.org/showcase/creative-edinburghs-connected-innovators>
- New Media Scotland: <https://creativeinformatics.org/participant/new-media-scotland>
- One Hundred Flowers: <https://creativeinformatics.org/showcase/meet-our-resident-entrepreneurs>
- Physical Audio: <https://creativeinformatics.org/participant/physical-audio>
- PicoJar: <https://creativeinformatics.org/participant/picojar>
- Ploterre: <https://creativeinformatics.org/participant/ploterre>
- Ray Interactive: <https://creativeinformatics.org/participant/ray-interactive>
- Refract Music: <https://creativeinformatics.org/participant/refract-music>
- Sarah Calmus: <https://creativeinformatics.org/showcase/creative-edinburghs-connected-innovators>
- Scottie: <https://creativeinformatics.org/participant/scottie>
- Sian Bevan: <https://creativeinformatics.org/showcase/creative-edinburghs-connected-innovators>
- Stageport: <https://creativeinformatics.org/participant/stageport>
- Stenz: <https://creativeinformatics.org/participant/splatform-limited-stenz>
- Tentop: <https://creativeinformatics.org/showcase/meet-our-round-3-resident-entrepreneurs>
- Thrifty: <https://creativeinformatics.org/showcase/give-it-up-for-our-round-2-resident-entrepreneurs>