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STATE OF THE ART

ANALYSING WHERE ART MEETS TECHNOLOGY USING SOCIAL NETWORK DATA

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SUMMARY

Technology has always been integral to art. Developments in oil paints during the Renaissance enhanced painting's realism and allowed painting on canvas making it more transportable. In the 19th century, the camera changed the role of representation in art. In the 20th century, recording technologies, the television and the internet took the performing arts from the stage, into the home and onto the streets. In the 21st century, technologies like 3D printing, the Internet of Things (IoT) and others may lead to equally radical changes - affecting the scope of what is possible and our conceptions of art, and the world, in new and unpredictable ways.[1]

This is of economic as well as aesthetic interest. Technological change can create completely new forms of economic activity and affect existing ones. The creative industries are a major UK employer and are growing faster than other sectors.[2] They are set to become even more important due to their reliance on skills that are resistant to automation.[3] Digital technology is affecting the whole of the creative industries, from commercial business-to-business sectors like advertising and design, through to subsidised arts and culture.[4 5] It is therefore important for the UK to try and understand what is happening more systematically at the interface of art and technology to inform strategic thinking on future skills needs, economic growth, and other issues of policy interest, such as the geographic makeup of the economy. To contribute to this, the report identifies and quantifies activities that are occurring at the intersection of art and technology in the UK, where these activities are happening and the connections between them.

Analysing and measuring this art-tech activity, however, poses challenges. Activities combining different skills and disciplines are intrinsically hard to study. They can span the boundaries between domains and are less well covered by established data sources such as surveys. Data from the social networking platform Meetup.com provides a way to address this. Meetup allows people to form groups ('Meetup groups) with others that have similar interests. These groups hold physical meetups ('Meetup events') around topics related to their group's theme. The data generated by these Meetup groups offers a systematic way to collect information on what people across the UK are currently meeting to discuss on a range of different topics. Nesta has previously used Meetup data to understand emerging trends in the UK tech sector.[6] The platform's data enables us to assess what topics at the interface of art and technology people are meeting about.[7] Where in the country this is happening? How many people are involved? And to what extent are different areas at the intersection of art and technology linked through people being involved in multiple domains?

There are clear limitations to what can be inferred from Meetup data. This data does not, of course, capture groups that do not use the Meetup platform and will under-represent groups and geographic areas that are less likely to use it. The data is also much less likely to capture relevant activities taking place within institutions such as companies and universities. This matters if activity inside institutions means people feel less need to engage with these topics outside of work or study, resulting in lower levels of activity on platforms like Meetup (although the converse can also be argued - that institutional activities in turn stimulate more activity in the surrounding areas). These limitations aside, the data gives us a readily available and potentially rich source of information to explore activities which would otherwise be hard to measure using traditional data collection methods such as surveys.

The report firstly discusses the general principles used to identify activities at the interface of art and tech, and then how these principles were operationalised to identify groups relating to them in the Meetup data. The findings on the number of activities involved, their geographic distribution, and connection through joint participation are then discussed, before concluding.

The research identifies a number of technologies as being at the interface of art and technology, including both hardware-related technologies such as the Internet of Things, virtual reality and 3D printing, and software-related technologies (for example music production, animation and design software). This is in addition to technology-related activity in the areas of filmmaking, photography, games programming, and wider digital creative activity. Although other geographical concentrations of art-tech activity are identified, the report finds that a high proportion of these activities are, at least in terms of Meetup activity, in London - this is even allowing for the fact that there are high levels of London Meetup activity in general. At a more local level, it is found that makerspaces are an area where artistic skills and new technologies are being combined. There is also evidence that the different activities analysed, while distinct, are connected by people who span the boundaries between the different areas. The research adopts a broad definition of art, although within this there appear to be comparatively limited use of newer technologies in the fine arts. A characteristic of a number of the technologies identified is that they enable greater personalisation and perhaps this will lead to tailored individual experiences being an increasingly important part of the arts in future.

1. THE PRINCIPLES THAT INFORMED THE IDENTIFICATION OF GROUPS AT THE INTERFACE OF ART AND TECHNOLOGY

We are interested in identifying artistic uses of technology that are more likely to be new and innovative, and hence offer growth potential in the future. There is inevitably an element of subjectivity in this, but the following general principles were applied to identify relevant Meetup groups. These relate to the artistic domains involved, the technologies used and the ways people engage with them. How the principles were operationalised in the data analysis is discussed in the next section.

Domains

- **A broad definition of art:** A broad definition of artistic activity has been adopted including areas like design, fashion, music, computer games and filmmaking as well as the more usual fine art. This recognises the fact that artistic skills are of importance in a host of different activities.

Technologies

- **Newer technologies:** As most artistic activity involves some form of technology, too general a definition of technology would result in the inclusion of almost any conceivable artistic activity and would therefore not be meaningful. To be included in the scope of the analysis the technology involved should therefore be relatively recent, e.g. traditional artistic tools such as watercolours would not count for our purposes. Alternatively, if not a new technology as such, the technology should be undergoing rapid transition, such as computer software.[8]

How the technology is being used

- **Creating not consuming:** A connection to some form creative activity is necessary for inclusion in the analysis. On this basis, making computer games would for example be included, but not playing them. Networking groups related to the creative activity, or which bring together art and tech professionals, are though considered for inclusion. This could for example include a creative tech meetup involving web designers, app developers and artists, or a meetup group devoted to learning a particular artistic software package.
- **A degree of technical skill is needed to use the technology:** Activities should involve a reasonably high level of technical skill to use the technology.

2. HOW THE ART-TECH MEETUP GROUPS WERE IDENTIFIED IN PRACTICE

Using the general principles above, the group information associated with Meetup groups are visually inspected. Each group on Meetup is associated with a mutually exclusive category that records the topic of the group. The Meetup categories inspected as part of the analysis (number of groups in parentheses) were: tech (1699), fine arts/culture (469), photography (223), fashion/beauty (100), career/business (1634), games (258), music (429) and movies/film (219).[9]

A number of technologies (both hardware and software) and domains related to the interface of art and technology were identified:

- Physical hardware related:
  - 3D printing (i.e. where 3D objects are printed from a digital blueprint).
  - Virtual reality.
  - Internet of Things (i.e. where physical objects have embedded sensors and network connections that enable them to collect and exchange data).
  - Digital video and photography.
  - Raspberry Pi and Arduino.
  - Makerspaces providing access to physical hardware.
- Software, examples of which are:
  - Music production e.g. Pro Tools and Ableton.
  - CAD design e.g. Rhino and Autodesk.
  - Photo editing e.g. Photoshop.
  - Creative coding frameworks e.g. openFrameworks and Cinder.
  - Graphics technologies e.g. WebGL.
  - Games engines e.g. Unity.
  - Data visualisation e.g. D3 JavaScript library.
- Domains:

  There are also a set of domains considered to be intrinsically related to the interface of art and technology:
  - Computer game development.
  - Visual effects and animation.
  - Data visualisation.

Groups associated with these technologies and domains are systematically identified in the data according to whether their information on Meetup contains words related to these activities (each group on Meetup has a textual description of its activities, and a set of keywords that describe the group's activities which appears under the heading 'We're about:'). These groups are then inspected to arrive at a final list.

We discuss each of the categories in turn, and some of the issues in identifying groups involved with them. The words used to identify the groups are listed in Appendix Table A.1.

2.1 Hardware

Which can be used for exclusively functional purposes as well as artistic ones

A number of the technologies we study have roles that can be purely functional. While functional uses are interesting in themselves, they are considered as outside the scope of this investigation and we therefore adopt techniques to try and identify groups that are more likely to be engaging in art-related activity.

Internet of Things: There are a number of groups that refer to the Internet of Things in their description and keywords. There are many potential uses of such technologies, which may in some cases be purely functional e.g. monitoring central heating or controlling traffic in cities. We therefore focus on those groups that also include art/design related words in their description or keywords.

3D printing, Raspberry Pi, Arduino and Makerspaces: These can have purely functional as well as artistic uses. Again we therefore consider them if there is also a reference to art and design-related words in either their description or keywords. Although not a technology as such, makerspaces are often associated with 3D printing, Arduino and other technologies. Groups that refer to makerspaces in their description or keywords are also considered if they include art or design-related words.[10]

Which has become ubiquitous in an area of artistic activity

Photography and Filmmaking: Digital photography is so widespread, and digital cameras so easy to use, that it is now hard to argue that in all cases this represents a new, or intensive, form of artistic engagement with technology (although of course it can be). Therefore, if there is evidence of photography groups engaging in more sophisticated photo editing activity and being focussed on technology, as evidenced by mentions of Photoshop/retouching/manipulation in their keywords or description then they are also considered. On a similar basis to photography, digital video/filmmaking per se is not enough to be considered, however additional discussion of editing and post-production is.

2.2 Software

Software dedicated to artistic activities: In the areas of music production, animation, games, photography, programming and design there are a number of standard software tools that are used. A list of these software packages is used to identify groups involved with this software.

More general software tools: Standard programming languages (e.g. Python, JavaScript, C++) can have a huge range of uses. These languages are obviously creative tools and certainly can be used artistically. However, they have a vast number of other uses that are not primarily artistic. There are also a large number of Meetup groups associated with web design, and while parts of web design clearly involve artistic aspects, it covers a lot of other areas too. Identifying groups that were more arts related in this context was operationalised by seeing whether the group keywords or descriptions in the tech category, that did not match any of the other areas being analysed, also matched any of the words relating to different artistic domains. This approach is applied to all groups in the tech category on Meetup to capture other technological activity involving artistic activity.[11]

2.3 Domains

Games programming, virtual reality and visual effects: These are considered to be domains that intrinsically combine newer forms of technology and artistic activity. They are therefore considered if synonyms for them are included in either of a group's keywords or description.

Data visualisation: A number of groups have information that indicates they are related to data visualisation. However, upon inspection these groups turn out to be very largely related to data analysis, rather than data visualisation as such. We therefore only treat these groups as in scope if both their keywords and group description contain a reference to data visualisation, indicating a greater focus on this area.

2.4 Finalisation of groups

The number of groups returned based on matching the words related to the different activities is given in Appendix Table A.2.[12] The resulting groups are then manually inspected and further anomalies removed.

A group is excluded if, for example, there are indications that the group contains a word with a potentially artistic meaning, e.g. design but where the activity being referred to is purely functional (e.g. electrical design) or artistic but insufficiently related to technology (e.g. game design where the 'design' relates to board games design). Alternatively, groups are excluded on visual inspection if their level of artistic/tech activity when studied appears to be fairly limited. In addition, a number of other groups not captured by the above classifications but which are considered relevant are included for example hardware based audio-visual tech groups, electronic music production groups that did not mention a specific software and some design groups not captured from the textual analysis.

This process results in 334 groups being identified as operating at the interface between art and technology.

These groups will not capture all UK artistic activity involving technology on Meetup. In particular, there will be groups engaging in art and tech where this cannot be inferred from their Meetup information (false negatives) and groups identified from their keywords or description where in practice art-tech is a small part of their group activity (false positives) e.g. a makerspace where both artists and technologists work, but on separate projects. More generally, ambiguity as to the meaning of keywords, such as design, may lead to groups being incorrectly classified. The approach adopted does, though, try to minimise the number of false positives, thus providing a starting point for understanding the phenomenon.

3. THE NUMBER OF DIFFERENT KINDS OF ART-TECH MEETUP GROUPS

The Table below gives summary information for the resulting 334 groups, the number of the groups that had textual information matching the different activities in the first column on the left and their associated membership numbers. The activities are not mutually exclusive - that is, the same group may be involved in more than one activity. The right-most column shows the other activity that groups which did the activity the row corresponds to was most commonly associated with (for example 22 of the groups involved in 3D printing also involved in makerspaces).

TABLE 1 **NUMBER OF GROUPS INVOLVED IN DIFFERENT ACTIVITIES**

Activity that the group is involved in	Number of groups where activity was identified	Number of members (Members of multiple groups will count more than once)	Activity that it was most commonly found to be associated with (Number of groups in brackets)
3D printing	28	8,614	Makerspaces (22)
Makerspaces	43	14,519	3D printing (22)
Raspberry Pi/Arduino	18	4,979	Makerspaces (13)
Internet of Things	15	6,503	Makerspaces (7)
Virtual Reality	26	8,203	Games programming (12)
Games programming	65	18,886	Arts related Software (17)
Arts related software e.g. Pro Tools, Maya, Revit	121	64,799	Digital photography (65)
Data visualisation	13	7,277	Visual effect works (1) Arts related Software (1)
Visual effects and animation	27	12,399	Arts related Software (13)
Video/Filmmaking	22	4,503	Visual effects and animation (5)
Photography	82	50,289	Arts related Software (75)
Art-related activity in the Meetup tech category not included in the above categories	44	18,681	NA
Other	26	5,734	NA
All	334 The total number of groups	134,548	NA

Groups involving arts-related software have the largest number of groups overall. They also had the largest number of members. However, many of these groups relate to Photoshop, so in practice there is a substantial overlap with digital photography, the next largest group. After this, in terms of the number of groups and overall membership, comes groups related to games programming.

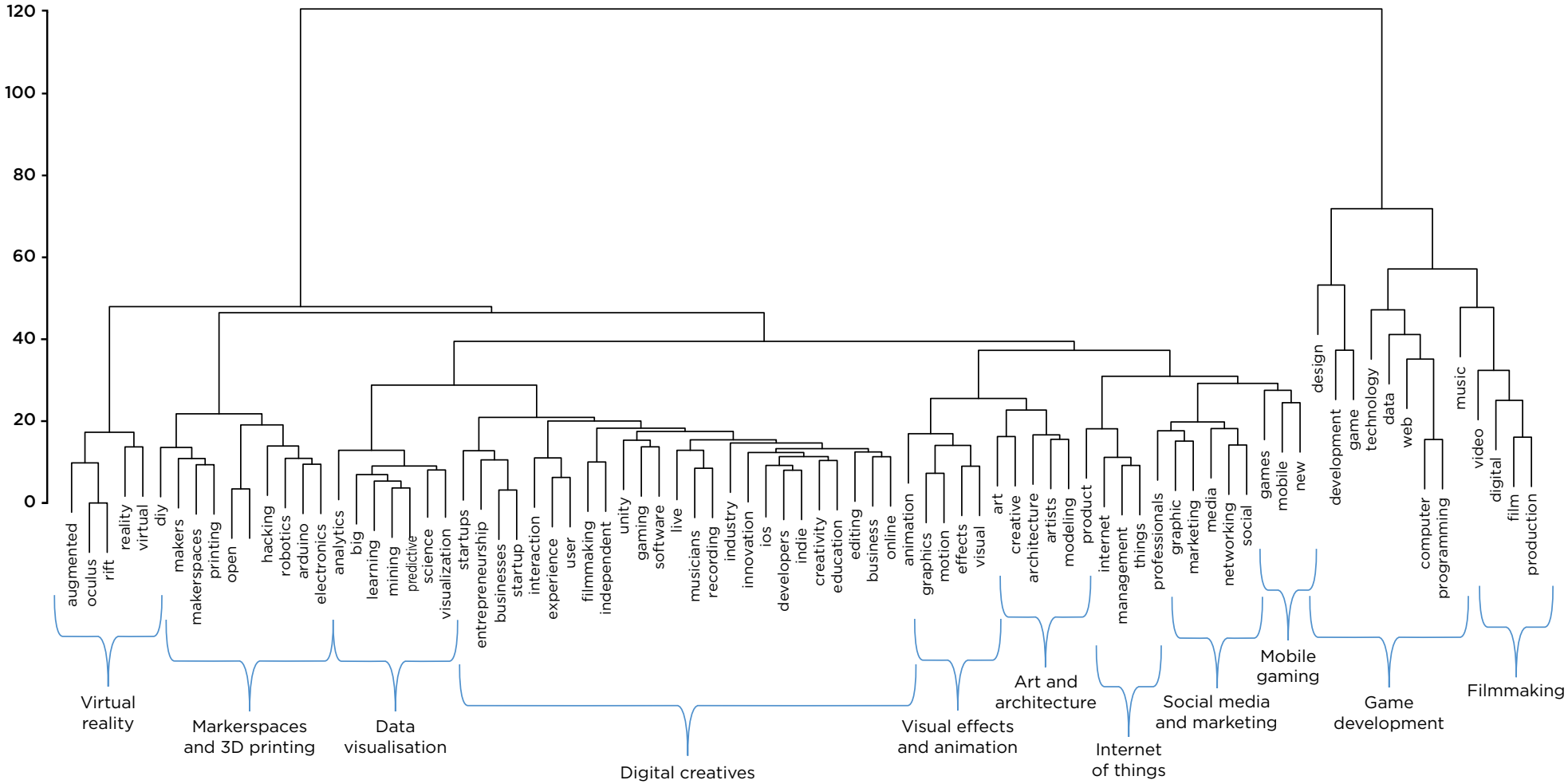
The art-related activity in the tech category which isn't otherwise captured contains several web-design groups whose information indicated a focus on graphic design. Activities relating to using tech in performance are not clearly identified within the above categories, but included groups relating to audio visual/lighting technology in theatres, the role of technology in storytelling and using YouTube to distribute creative content. There were also a small number of groups relating to fashion and tech, with a particular focus on wearables technologies and innovations in textiles.

Connections between groups' information

To try and categorise the relationships between the different activities we undertake, a hierarchical cluster analysis of the groups' keywords.[13] This approach first takes the set of the most common individual keywords across all the groups and then combines words that most frequently appear together within groups' keywords. This leads to the words being allocated to a smaller set of clusters, which are then combined together again according to which clusters contain words that are most commonly used together. This process continues until all the clusters are merged into a single cluster.

Figure 1 below shows the resulting hierarchical clusters that emerge. The words shown are the most common sets of words across the groups. In the hierarchical cluster analysis the words that appear more frequently together are connected by being on branches joined by the same stem. Photography-related words are found to constitute a cluster that is very distinct from the others, so to make the diagram clearer, they are omitted from the analysis.[14]

FIGURE 1 CONNECTIONS BETWEEN THE WORDS DESCRIBING DIFFERENT KINDS OF ACTIVITY



The Figure shows that words related to markerspaces and 3D printing and Arduino often appear together. There are also distinct clusters of words related to game development and filmmaking. There are a set of words grouped under the heading of Digital creatives that relate in part to commercial activity, and a distinct cluster of words related to visual effects and animation. That activities may appear distinct in the clusters does not mean that they are technologically unrelated, e.g. game development and virtual reality do have connections, but it does show there tend to be separate Meetup groups related to them. We will examine the connections between groups in terms of them having members in common later in the document.

4. WHERE ARE ART-TECH MEETUPS HAPPENING?

The groups are not evenly distributed around the country. Table 2 below shows the urban areas that have the most groups according to their location information on Meetup.[15]

TABLE 2 **THE NUMBER OF GROUPS BY CITY IN DESCENDING ORDER**

	London	Bristol	Manchester	Brighton	Oxford	Other[16]
Number of groups	196	10	9	8	6	105

London is by far the largest location of these Meetup groups, accounting for 59 per cent of them. The place with the next largest number of groups, Bristol, accounts for 3 per cent of the groups. A large number of Meetup groups in these areas could though just reflect geographic variations in wider Meetup activity, not in art-tech related activity specifically.

We adjust for this using Location Quotients (LQs), which are calculated by the proportion of all groups in art-tech that fall within a given area divided by the proportion of all groups on Meetup in these geographic areas.[17] The results are shown in Table 3. An LQ of more than (less than) one means that the area has a higher (lower) proportion of groups in the art-tech category than its share of all Meetup groups i.e. there are more such groups than one would expect on the basis of Meetup activity overall. In the final column of Table 3 we also calculate the LQ in terms of the number of Meetup group members i.e. the proportion of the membership numbers that are in art-tech Meetups in an area vs the proportion of all Meetup members in that area as a whole.

The geography we use is Travel to Work areas (TTWAs), which are geographies that capture the commuting area around urban centres.[18] A number of the TTWAs have small numbers of (or no) Meetup groups and smaller still numbers of associated art-tech Meetup groups. LQs based on small sample sizes are very volatile so it is not really meaningful to map them for the UK as a whole. We therefore present location quotients only for those TTWAs with the largest number of art and tech Meetup groups.

TABLE 3 LOCATION QUOTIENTS OF ART-TECH GROUPS IN THE UK BY TRAVEL TO WORK AREA (SORTED BY THE TTWAS WITH THE LARGEST NUMBER OF ART-TECH GROUP)

	Location quotient	Art-tech Meetup groups	Number of Meetup groups	Art-tech Meetup groups (membership numbers summed)	Total Meetup group membership (membership numbers summed)	Location quotient in terms of members
London	1.2	201	7,725	103,792	3,570,916	1.1
Bristol	1.6	11	311	2,471	98,863	0.9
Manchester	0.9	10	476	6,332	177,396	1.3
Brighton	1.1	9	380	2,618	92,819	1.1
Cambridge	1.3	7	233	1,310	48,847	1.0
Oxford	1.4	6	187	1,908	41,623	1.7
Liverpool	2.0	5	110	1,366	28,700	1.8
Edinburgh	0.6	5	397	2,005	121,519	0.6
Birmingham	0.5	4	336	749	107,242	0.3
Crawley	1.7	4	108	741	10,301	2.7
Guildford & Aldershot	1.0	4	175	1,004	30,400	1.2
Reading & Bracknell	0.8	4	213	536	36,326	0.6
Southampton	1.3	4	139	696	19,754	1.3
Southend & Brentwood	2.7	4	66	496	8,668	2.2

Note: The membership numbers presented in this table will count individuals that are members of multiple groups more than once.

London has an LQ of more than 1 which shows that its high number of art-tech Meetups is not simply a reflection of its much larger number of Meetup groups i.e. it still accounts for a higher proportion of art-tech Meetup groups than would expect on the basis of its number of Meetup groups. Analysing the location quotient in terms of the number of group members results in a similar story. Although the correlation is not perfect, areas having a location quotient of more than 1 in terms of the number of groups also tend to have a higher LQ for Meetup members.

Appendix Table A.3 shows that if we examine the groups in the Meetup fine art/culture categories and groups in the separate tech category, then London has both more fine art/culture groups and more tech groups than one would expect on the basis of its number of Meetup groups alone. The high level of art-tech activity is consistent, with London having both more groups related to art and more groups related to tech.

These findings are also broadly consistent with Nesta's previous work on the UK's high-tech and creative economies.[19] A number of the areas of high art-tech Meetup activity identified here (e.g. London, Brighton and Bristol) are also areas we have identified as major employers in the creative or high-tech economies, after adjusting for the size of the workforce. However, there are exceptions to this rule: Edinburgh and Bracknell and Reading, for example, are typically found to have disproportionately high levels of creative and high-tech employment, and yet do not have a disproportionately large number of art-tech Meetup groups. This may though just reflect the sample sizes involved being relatively small.

5. THE RELATIONSHIPS BETWEEN GROUPS AT THE INTERFACE OF ART AND TECHNOLOGY

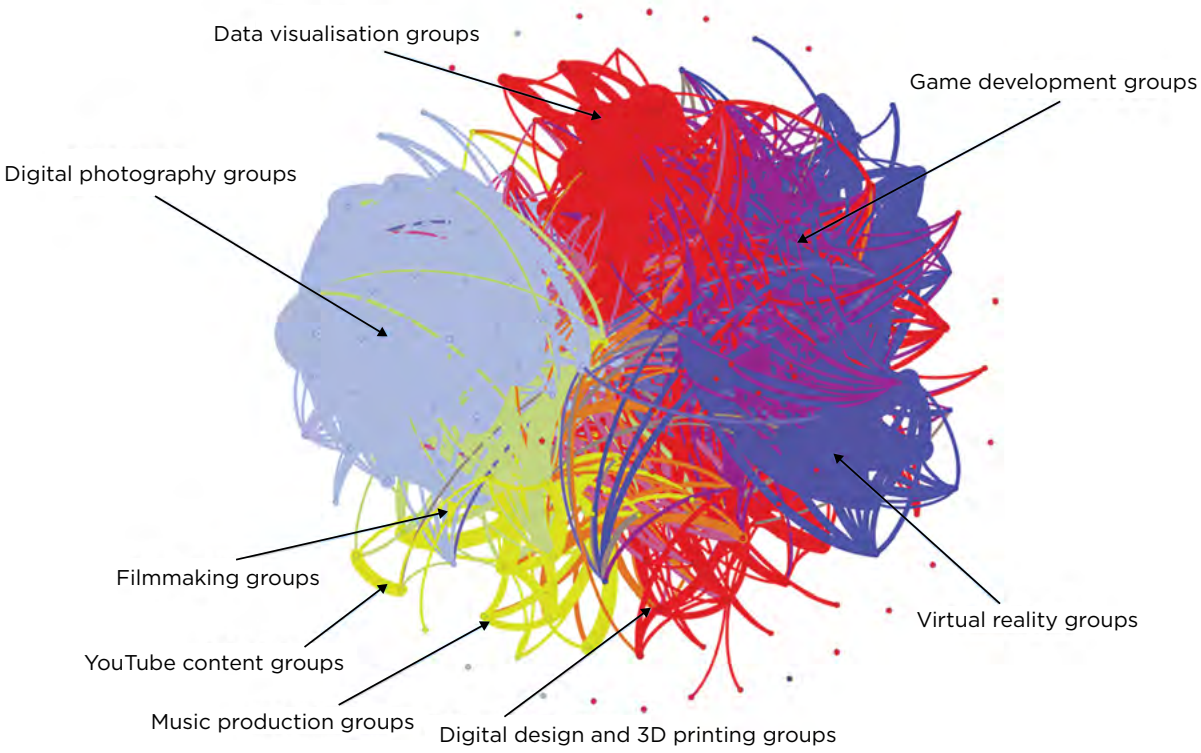
To understand the connections between groups we look at which Meetup groups are connected by having members in common. We use the group identifiers to obtain a list of associated members of the art-tech groups, extracting data on 85,206 people that are members of them.[20]

If we analyse the members of these groups, we find that 61,468 people (72 per cent) are members of one group only within the art-tech groups; 12,812 people (15 per cent) are members of two groups and 10,926 (13 per cent) people are members of three or more groups.

To analyse the patterns of cross participation, we look at connections among London Meetup groups only. This simplifies the analysis, but also includes the set of groups where there are most likely to be a large number of joint members i.e. in other cities, where the number of Meetups is much smaller, the scope to be a member of multiple groups is necessarily more limited. This analysis complements the cluster analysis in Figure 1 which highlighted the topics that tended to appear together in group keywords, but which will not reflect whether different kinds of Meetup groups are connected by the same people attending them.

We plot the groups with connections between them, where they have more than ten members in common in Figure 2. Ten members in common is in the upper quartile of the distribution of the joint membership numbers between London groups. The network has been coloured with a clustering algorithm, with sets of groups that are more closely connected to each other (i.e. have more members in common) being the same colour. A set of distinguishable, but connected, communities emerge.[21] The chart labels correspond, in general terms, to the kinds of groups in different parts of the network.

FIGURE 2 ART-TECH MEETUP GROUPS IN LONDON CONNECTED BY HAVING MORE THAN TEN MEMBERS IN COMMON



There is a distinct, closely connected, set of groups related to photography. There is another community related to games and virtual reality which have members in common. Between these are groups related to filmmaking, digital design, 3D printing, fashion-tech and data visualisation.

These connections are only capturing the behaviour of the minority of people that are members of multiple groups. Some of these connections will not reflect active connections between groups as it is possible to be a member of multiple groups on Meetup without participating actively in them. Larger groups will also be accounting for more of these connections as they are more likely to have members that belong to multiple groups. Nevertheless the connections between the different groups is suggestive of connection by common interests and, perhaps, common artistic and technical skills due to digital convergence.

6. CONCLUSIONS

Activities involving both art and tech are unevenly distributed around the country

The groups identified on Meetup at the interface of art and tech, are primarily in urban areas, and predominantly in London. Part of the reason for the large number of art-tech meetups in London is that the platform is used much more in London, but the number of London art-tech meetups is still larger than would be expected on the basis of general Meetup use alone.

One of the explanations is likely to be that these activities require a blend of different skills that larger urban areas, due to their greater population and population density, have access to and can combine more easily. London is almost eight times larger than Birmingham, the second largest city in the UK.[22] It is the biggest and most international city in Western Europe, with a population approximately two and half times the size of either Berlin or Madrid, the next largest cities. Previous Nesta research has also shown that London accounts for a large and disproportionate percentage of the UK's employment in creative and high-tech industries, providing the skills one would expect to be behind a lot of activity where art meets technology. Perhaps we should therefore not be surprised at how much London also dominates art-tech Meetup activity.

Activities at the intersection of art and tech are connected by individuals that span the border of several domains

A variety of seemingly distinct domains of art and technology are connected by joint membership of Meetup groups among those groups located in London. Some members of digital photography groups are also members of visual effects and animation meetups, for example. People involved in 3D printing groups can also be members of game meetups. While the analysis does not measure the level of engagement of individuals across groups, the finding perhaps reflects a general trend of integrated artistic and technical skills which is finding expression in a host of domains.

Makerspaces are one of the places where activities that combine art and technology are happening

Although this report does not directly cover activities within institutions, it is striking that one of the places where artistic and technology skills are being combined is in makerspaces. Given the growth in some of the technologies associated with makerspaces, such as 3D printing, and the growth of the maker movement itself, it seems plausible that makerspaces will play an increasingly important part of activities combining art and technology in future.

The comparative absence of newer technologies relating to fine art

While we adopt a broad definition of art, it is though notable how little art-tech activity we have uncovered that is explicitly related to fine art (only 17 of the 334 groups identified were in the Meetup fine art/culture category vs 175 in the Meetup tech category). This may of course partly reflect that Meetup as a platform is not widely used by artists.[23] In the sample of Meetups we study there are 1,699 tech groups compared with 469 fine arts/culture groups, which is consistent with this. This may, however, also raise questions about how widespread are the use of new technologies in fine art communities, and whether this is an area where there are opportunities for more work combining the two.

The technologies highlighted suggest that personalisation is likely to be an ever more important trend in the arts

A characteristic of a number of the technologies examined: virtual reality, the Internet of Things and 3D printing is that they can offer a personalised experience to the individual by allowing it to be influenced by user feedback or enabling direct co-creation. An individual experience is already a characteristic of computer games, and it is arguable that as these technologies become pervasive that they will bring an increased level of personalisation to other domains. The finding raises the intriguing possibility that personalised experiences will become an important part of people's engagement with art.

APPENDIX

Rules used to identify the Meetup groups that did the activity

TABLE A1 WORDS USED TO IDENTIFY GROUPS ON MEETUP

Group activity	Activity identified based on matching:	Words used for identification
3D printing	Synonyms for the technology and art/design appearing in keywords or description	3D printing, cnc, 3D printers
Makerspaces	As above	hackspace, maker space, makerspace, makerspaces, makers, fablab
Raspberry Pi/Arduino	As above	raspberrypi, raspberry pi, arduino
Internet of Things	As above	internet of things, iot
Virtual reality	Virtual reality (or synonyms) mentioned in keywords or description	virtual reality, vr, oculus, augmented reality
Games programming	Games programming (or synonyms) mentioned in keywords or description	games programming, games coding, games modding, games development, modding (and singular versions)
Arts related software e.g. Pro Tools, Maya, Rhino, Photoshop	Software packages in keywords (as software packages routinely featured in the keywords this was used to identify these groups)	unreal engine, unity, frostbite, cryengine, rhino, photoshop, cinder, blender, ableton, pro tools, protools, webgl, autodesk, autocad, d3, maya, renderman, revit, logic, logic pro, cinder, cad, openframeworks, creative coding, katana, modo, zbrush,vray, v-ray, nuke, houdini, 3d studio max, 3ds max, adobe creative suite, pftrack, soundforge, sound forge, archicad, sketchup, cubase
Data visualisation	Data visualisation (or synonyms) in keywords and in description	data visualization, data visualisation, data journalism, data journalists, data visualisers, data vizualisers
Visual effects and animation	Visual effects (or synonyms) in keywords or in description	3d modelling, cg artists, vfx, cgi, visual effects, 3d animation
Video /Filmmaking	Filmmaking and additional reference to editing and post-production in keywords or description	digital video, filmmaking, post-production, editing
Photography	Words related to image manipulation in keywords or description in addition to photography	photography, photoshop, retouching, manipulation
General artistic domain keywords used to check connection with art		art,design,artists,designers,sculpture, fashion,music,musician, architecture, architects,

TABLE A2 NUMBER OF GROUPS IN MEETUP IDENTIFIED AS ART AND TECH ON THE BASIS OF MATCHING WORDS ALONE

Activity	Number of groups identified as art-tech (post inspection)	Number of groups based on matching the art and technology words in the table above (pre inspection)	Number based on matching technology words alone (no requirement to match artistic keywords)	Reason for where there is a substantial discrepancy between pre and post inspected number.
3D printing	28	31	54	
Makerspaces	43	97	201	Many of the groups matching 'makers', but were less clearly tech related
Raspberry Pi/Arduino	18	21	78	
Internet of Things	15	26	80	
Virtual reality	26	31	N/A	
Games programming	65	92	N/A	
Arts related software e.g. Pro Tools, Maya, Rhino, Photoshop	121	137	N/A	
Data visualisation	13	17	N/A	
Visual effects and animation	27	51	N/A	
Video\Filmmaking	22	43	N/A	The technology focus of a number of these groups appeared fairly limited.
Photography	82	83	N/A	
All	334 (removing duplicates across classifications)			

TABLE A3 LOCATION QUOTIENTS FOR THE STANDARD MEETUP ART AND TECH CATEGORIES

	Fine art/culture category group number	Fine art/culture LQ	Tech category group number	Tech category LQ
London	283	1.2	994	1.1
Bristol	6	0.6	56	1.6
Manchester	24	1.6	69	1.3
Brighton	13	1.1	26	0.6
Cambridge	5	0.7	58	2.2
Oxford	6	1.0	41	1.9
Liverpool	6	1.7	17	1.3
Edinburgh	12	1.0	35	0.8
Birmingham	8	0.8	39	1.0
Crawley	2	0.6	5	0.4
Guildford & Aldershot	5	0.9	6	0.3
Reading & Bracknell	5	0.7	19	0.8

How quickly are they growing?

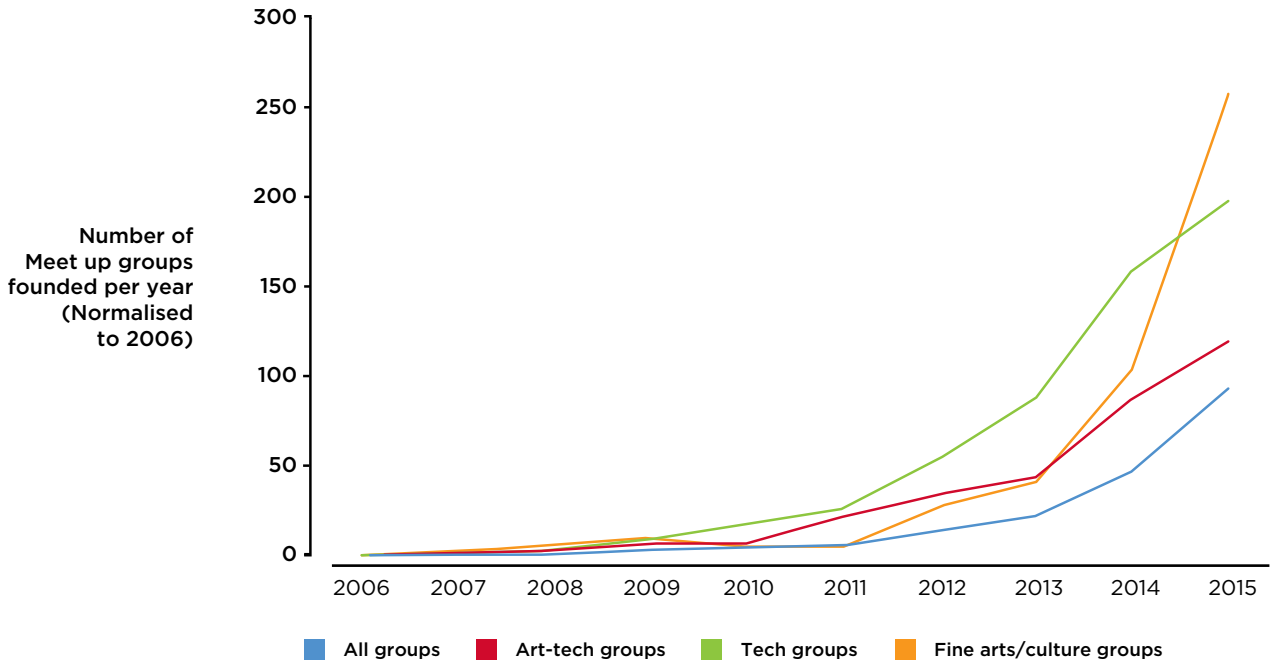
Table A4 below shows the year that the art-tech groups were started. Around three-quarters (76 per cent) of the groups were set up in the last three years. By comparison, 82 per cent of Meetup groups in the UK were set up in the past three years, so although this is a rapid rate of growth it is reflective of the rate of growth in the Meetup platform as a whole.

TABLE A4 NUMBER OF ART-TECH MEETUP GROUPS OVER TIME

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	2	4	8	8	23	35	45	88	120

Figure A1 shows the growth rates of different groups on Meetup, rebased to 2006 when we have our first Meetup group in the art-tech category.

FIGURE A1 **THE GROWTH RATE OF ART-TECH GROUP COMPARED TO OTHER UK GROUP CATEGORIES ON MEETUP (NORMALISED TO 2006, THE FIRST YEAR WE HAVE ART-TECH GROUPS FOUNDED)**



Since 2006, the number of groups in the art-tech category has grown faster than the number of UK groups on the Meetup platform, which has experienced very rapid growth itself, although not as fast as the groups in the platform's tech or fine arts/culture category. It is, though, also true that the number of groups involved is by definition smaller than that on the Meetup platform as a whole, so this growth in absolute terms corresponds to far fewer groups than the increase in total Meetup groups in the UK.

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ENDNOTES

1. For examples of some of the ways new technologies are being used in the arts see: Openshaw, J. (2015) 'Postdigital Artisans: Craftsmanship with a New Aesthetic in Fashion, Art, Design and Architecture'; Johnston, L. (2015) 'Digital Handmade: Craftsmanship and the New Industrial Revolution'; Klanten, R., Ehmann, S. and Hanschke, V. eds. (2011) 'A Touch of Code: Interactive Installations and Experiences'; Dunn, N. (2012) 'Digital Fabrication in Architecture' and Reas, C. and McWilliams, C. (2010) 'Form and Code in Design, Art, and Architecture.'
2. Bakhshi, H., Davies, J., Higgs, P. and Freeman, A. (2015) 'The geography of the UK's high-tech and creative economy.' London: Nesta, and Nathan, M., Pratt, A. and Rincon-Aznar, A. (2015) 'Creative economy employment in the EU and the UK.' London: Nesta.
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6. Mateos-Garcia, J. (2015) 'Using Meetup data to explore the UK digital tech landscape.' Nesta blog.
7. The data was collected by querying the Meetup API in November 2015 for all Meetup groups with a location falling within a circular area that contained the UK and which also had the country ID, GB (this being the country ID used by Meetup for the UK). This resulted in a total of 14,800 Meetup groups being returned across all Meetup group categories.
8. Some of the relationships between art and computer technology are older than they may at first appear, for example, what is widely recognised as the first UK exhibition of art related to computer technology, Cybernetic Serendipity, was held at the Institute of Contemporary Arts (ICA) in 1968. In addition, 3D printing has been around in various forms since the 1980s and head-mounted displays, a central part of virtual reality, have been in existence since the 1960s.
9. Given the number of groups involved as part of this initial inspection to help identify potentially relevant groups a support vector machine was trained on the Meetup groups identified as falling within the interface of art and tech by an initial visual inspection of the groups with the groups' keywords acting as inputs. The resulting classifier was then run on the entire set of Meetup groups downloaded for the UK to flag up other possible groups involving art and tech that might be relevant.
10. Sleigh, A., Stewart, H. and Stokes, K. (2015) 'Open dataset on UK Makerspaces: A user's guide.' London: Nesta.
11. In practice this approach largely picked up web design groups that also had a focus on graphic design.
12. Words were set to lowercase and extra whitespace removed to do this.
13. Words were set to lowercase and extra whitespace removed to do this. Only words that appear in at least 5 per cent of groups are considered.
14. This is done by omitting groups that were found to contain activities that match the words used to identify photography.
15. Each group on Meetup has a location information field corresponding to the city that the group is in.
16. The other category split by region corresponds to 24 groups in the Eastern region, 23 groups in the South East region, 16 in the North West, 11 in Scotland and the rest distributed across other regions of the UK.
17. These LQs were calculated for those TTWAs where there was at least one Meetup group. The groups have a longitude and latitude, so how they are distributed across the different TTWAs in the UK can be calculated.
18. The current criteria for defining TTWAs is that generally at least 75 per cent of an area's resident workforce work in the area and at least 75 per cent of the people who work in the area also live in the area. http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/other/travel-to-work-areas/index.html
19. Bakhshi, H., Davies, J., Higgs, P. and Freeman, A. (2015) 'The geography of the UK's high-tech and creative economy.' London: Nesta. These areas were also identified as hubs of the UK games industry in Mateos-Garcia, J., Bakhshi, H. and Lenel, M. (2014) ' A map of the UK games industry.' London: Nesta.
20. As measured by unique user IDs.
21. The analysis was undertaken using the graph modularity algorithm in gephi. The algorithm partitions the graph's nodes into a set of communities (i.e. each community being a group of nodes) that aims to maximise modularity of the graph. The modularity being the number of connections that fall within communities for a given partition relative to the expected number of connections within the communities if connections were generated at random. A community partition characterised by higher modularity is thus less likely to have arisen by chance.
22. Source for all cities population data in this paragraph is Eurostat 2014 statistics.
23. A way to address this in future could be by analysing activity on another online platform such as Eventbrite.

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