

Creativity Studies on the Reactable online community

Assessing the validity of distributed creativity models in an online community of creators

UPF MASTER THESIS / 2013

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Acknowledgments

I wish to thank my supervisor Sergi for making this project possible through his tireless support, patience and interest in exploring whatever strange theory I was trying to get into. I would also like to thank everyone from the Reactable systems team, for providing me with the data for such a fascinating system to study, and to Thodoris, Marcos, Mathieu and Andres for their assistance and promptness to resolve any doubts I had. Thanks to Lucas for his interest and critical thinking.

My thoughts go out to my family and friends from CSIM, hoping I will share more of the excitement and passion for the systems that we shape and shape us.

Abstract

The current thesis presents a creativity study of the online community built around the Reactable mobile application. By exploring the relationship between social exposure and creative production patterns as suggested by various frameworks for fostering distributed creativity, we assessed the validity of said models in the context of an online community of creators, by looking at predictors for both social influence and psychological creativity. We report on the Reactable community specificities and on how it shines light on contemporary cultural practices on the Internet for creators intending to showcase their work and create network bonds with their peers. Users's work that rely on previous work tends to be more appreciated, spread more, although their psychological creativity score is not significantly different.

Keywords : Reactable, online communities of creators, distributed creativity, autopoiesis systems, mobile music production,

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1. INTRODUCTION

1.1 Problem Statement

In an era where boundaries between producers and consumers of culture are becoming everyday blurrier, and the transmission of culture has become equally important as its production, the case for creativity in a distributed context is inevitable. With the Internet and the emergence of distributed creativity, notions of authorship, copyright and fixity of cultural artifacts are questioned. Cultures of participation are a very active field of investigation, mostly driven by innovative business research in the knowledge economy trying to make the best out of this new economic paradigm (Fischer 2005, Faraj et al. 2011, Florida 2002).

On the other hand, creativity studies, although more than 60 years old already, still suffer from lack of a clear definition for what is creativity, and its assessment is still at an early stage. There is no real consensus over what class of entity is being studied, and psychological and social approaches emphasize different, apparently irreconcilable aspects of creativity (Klausnen 2010). Creatology (Iba 2010) proposes a new way to looking at creativity using autopoietic systems theory (Luhmann 1984, Maturana & Varela 1980), adding a third element to the equation, the *creative system*. Using systems theory, non-original creations are creative as long as they contribute to the autopoiesis of the creative system by successive discoveries.

Assuming *systems exist*, we studied the coupling of sociological, psychological and creative systems in a distributed setting where creators share, download, rate, remix and get inspired by others creations. The domain, supported by the constant creation of new tables that spread and are exoised through the Reactable Community website, gives hints to users as to what possibilities the application offers, and how to make music in order to be established within the field. The Reactable community offers a unique opportunity to study the systems because of the detail and amount of data available on psychological, sociological and creative behaviors of its members. We analyzed patterns of individual creative behavior, social behavior, and transmission of knowledge on the platform to find out what may be driving the autopoiesis of the reactable social and creative systems.

1.2 State of the Art

a) Psychological view

Boden defines creativity by its chief attributes as “the ability to come up with ideas or artefacts that are new, surprising and valuable”. (Boden, 2004). Creativity is generally associated with self-determination, intrinsic motivation and mastery (Amabile 1998, Csikszentmihalyi 1996, Robinson 2001, Nickerson 2009) in goal-oriented contexts such as education or the workplace. As the result of a heuristic process, where the goal is not necessarily clear every step of the way (Amabile 1996), it is best facilitated by providing a nurturing environment, where small rewards coming from the work produced maintain intrinsic motivation, and the right amount of challenge is matched with the right amount of skills to maintain flow (Csikszentmihalyi 1996). The creative process is about a specific use of associative memory. It is sometimes equated in the literature with divergent thinking (Guilford, 1967). The Torrance Tests of Creative Thinking, based on Guilford's theory, originally involved simple tests were scored on four scales: fluency, flexibility, originality and elaboration. They are criteria of creative thinking and not of a creative product. In that sense, they are not necessarily predictors of an eminently creative product, but rather taken as evidence of a creative process, which is the tendency to come up with multiple answers to a set problem. Boden emphasizes the need for *exploration* and *transformation* of conceptual spaces in people's minds (Boden, 2004). Gabora's Honing theory (2009) explains that by describing the creative process as the process by which worldviews tend to resolve states of potentiality through self-organized transformation. As the worldview self-modifies through the interaction of the idea with newly generated contexts, new associations are made and insight is eventually triggered when the *percolation threshold* is reached in the graph of ideas and associations. Then a more analytical approach is needed, following a *search and select* heuristic where the smarts is not in the *generation* but in the *selection* of ideas. It is coherent with Wallas's widely accepted 4 phase model of the creative process (Wallas, 1926), *preparation* and *incubation* corresponding to the first stage, *illumination* to the moment the percolation threshold is reached, *verification* being essentially a *search and select* process.

Although mostly studied as the internal cognitive process of an individual as seen previously, creativity is generally recognized to be widely dependant on social acceptance. Klausen raises the difficulty of dealing with a *response-dependent phenomenon* (Klausen, 2010), where *realist* and *anti-realist* views are opposed. Either the creative person, process or product is creative independently of how it is experienced by a social circle, or it is not. Both views do not allow to determine where creativity is *achieved*. According to Csikszentmihalyi (1999), there is no way to separate the reaction of society from the person's contribution. When studying eminent individuals, some common traits that have been found include *access to the field* and *support* from a specialized community or individual (Gardner, 1993; Csikszentmihalyi, 1996). But for ones who made an unprecedented contribution to human culture, where the success of a meme is indistinguishable from its acceptance, creative thinking is not a guarantee of a historical achievement. P-creativity (Boden, 2004) is an idea that's new to the person who comes up with it. Many other people may have had that idea before, but if a new idea is H-creative, that means that no-one else has had it before. To Boden, *h-creativity is a special instance of p-*

creativity.

b) Distributed creativity

Csikszentmihalyi, on the other hand, describes it more in terms of its effect, saying that creativity is “when a person, using the symbols of a given domain, such as music, engineering, business or mathematics, has a new idea or sees a new pattern, and when this novelty is selected by the appropriate field for inclusion into the relevant domain”. (Csikszentmihalyi, 1996) Through the 1990s, a second wave of creativity research pursued the idea that creativity is embedded in social groups, that creative products emerge from collaborative networks. (Farrell, 2001; Paulus & Nijstad, 2003, Sawyer, 2003 and 2009). Distributed cognition (Hutchins, 1995) is generally studied as a phenomenon emerging within a group sharing a common objective, i.e. producing a unique end-result, and where more often than not its participants share the same physical space. Similarly, drawing from debates on philosophy of the mind and how to account for the supervenience of mind that can't be explained by the activity of individual neurons only, Sawyer (2003) argues for *non reductionist individualism*, saying that although social events *supervene* on the individual level, they can also be the *cause* of individual events. *Distributed creativity* (Sawyer and DeZutter, 2009) is the view that in a creative process involving various individuals, that generates a creative product needs not be determined by the contribution of each participant. Fischer et al. (2005) state that the role of the individual in creativity is highly overrated, and that it is the combined efforts of the society that are the true source of creativity. Opposing the *Division of Labor* approach to collaboration (Levy & Murnane, 2004), where the collective outcome is *equal* to the sum of individual efforts, social creativity is a matter of emergent interactions and meanings, where the collective outcome is *superior* to the sum of individual efforts. To bring social creativity alive, Fischer continues, “cultures of participation need to be fostered and supported with socio-technical environments that allow stakeholders to act as designers, contributors, and decision makers in personally meaningful activities.” Meta-design is supposed to allow individual to be naturally creative by promoting commitment of all stakeholders who freely and fluidly associate with several fairly autonomous groups. It is committed to emphasize personal motivation through self-determination.

c) Online communities

Based on analyses of several online platform such as Wikipedia and Flickr, The *reader-to-leader framework* (Preece & Schneidermann, 2009) describes how to motivate social participation in online communities by the identification with successive involvement patterns, starting with *venturing in*, *browsing*, *reading* (reader), then *rating*, *posting*, *uploading* (contributor), *developping relationships*, *working together* (collaborator), and finally *promoting participation and mentoring novices* (leader). Online leaders typically contribute to the largest number of comments and are the most active. A design feature that promotes contributions is visibility to the author and community, possibly with the contributor being identified by a login name. This visibility offers contributors recognition that adds to

their social presence online, which has been observed to motivate tagging (Ames and Naaman, 2007; Nov et al. 2008) or editing contributions (Nov 2007), in turn, creating a growing reputation (Farzan et al., 2008). Typically leaders, although representing a small minority of the platforms population, contribute to most of the platforms content (Ortega et al. 2008). Thus, acknowledging, recognizing, and rewarding contributions and, in so doing, enabling the contributors to stand out (Hemetsberger 2001; Kollock 1999; Huffaker 2007) are variables thought to encourage online contributions by some scholars (Kollock 1999; Lampel and Bhalla 2007; Kolbitsch and Maurer 2006). These principles are reminiscent to Free and open-source software philosophies, but also seem to inherit from a traditional organizational view of creativity. The organizations associated tended to situate their members within strong organizational relationships that might not exist in massive decentralized or informal, non-goal oriented creative communities. Many members of the organizations favored in traditional creativity research share a similar past, in the sense that they have similar backgrounds (e.g., collegiate degrees and professional knowledge). (Pace et al, 2013) They promote a sort of “organized self organization” which is quite different from the functioning of truly grassroots FLOSS initiatives, where a continuous absorption of the developers practice by *the periphery* is necessary in order for the project to live on, but without initial planning whatsoever. (Rullani and Haefliger 2013).

d) Online communities of creators

The fairly recent emergence of the *Online Communities of Creators (OCOCs)* (Sylvan 2007) would then seem to offer a more appropriate model for the Reactable online community. In OCOCs, the core activity revolves around personal creations. Three main abilities characterize such platforms: the ability to share creations, the ability to comment on and discuss each other's work, and the ability to associate particular contributions with the people who make them. Examples of OCOCs include Flickr, Minecraft, Youtube or the community around the Scratch programming language (Sylvan, 2010). Studying OCOCs, Sylvan mapped specific behaviors of participants to Roger's (1995) five stages of adoption of innovations: awareness, interest, evaluation, trial and adoption, which also easily map to Preece and Schneiderman's *reader-to-leader* framework (2009). Her focus being on learning, she studied how users influence and reuse one another's work and how this contributed to children's learning and integration in the community using social network analysis. *Project Influence* and *Social Influence* received differentiated treatment, one being operationalized as number of downloads for every project, the other as *betweenness centrality* (Freeman, 1977). Both were found to be positively correlated, although reactions to appropriation of code from other users received mixed reactions, from anger to assentment. In another study of the Scratch community, Monroy-Hernández and Hill (2010) discovered that a positive attitude when remixing projects or framing community guidelines seemed to assure a more reliable functioning. From a more organizational approach again, in a comparative study of two OCOCs for music remixing (although the study simply refers to them as *online communities*), one firm-led (nin.com), the other community-led (ccmixter.com) Jarvenpaa & Lang (2011) found that, the *power boundary*, more open ended, with a clear reuse arborescence and a lower emphasis on identity in ccmixter permitted a higher *generative* capacity. They refer to the tension between *control*

and *growth*, that allows stronger creativity, as West and O'mahony claim (2008) although they provide no evidence for it. According to Pace et al (2013), in their study of Etsy, a craft and arts online community, it seems principles from the *reader-to-leader* framework (Preece and Schneidermann, 2009) can also be applied OCOs, as long as they are supporting the open-ended nature of such platforms (Luther and Bruckman, 2008).

e) Autopoietic systems

Recent years have seen a reappraisal of autopoietic systems theory to analyse knowledge collaboration in a distributed setting (Hall & Nousala 2007), (Mingers & White 2010)(Vines & Hall 2007) and in open-source communities (Pankowska 2011). Originally developed by biologists Maturana and Varela (1980), autopoiesis is the theory of living organisms as self-sustaining sustaining systems owing to an inner network of reactions that constantly re-generate all of the *autopoietic unit's* components. It is a functional description primarily intended for small organisms such as cells not centered on DNA, RNA and replication but rather on the continuous transformation that maintains the autopoietic unit : the living unit is open from the physical point of view (matter and energy are exchanged with the environment), but *operationally closed* (the network of transformations is physically contained within/maintains the boundary).

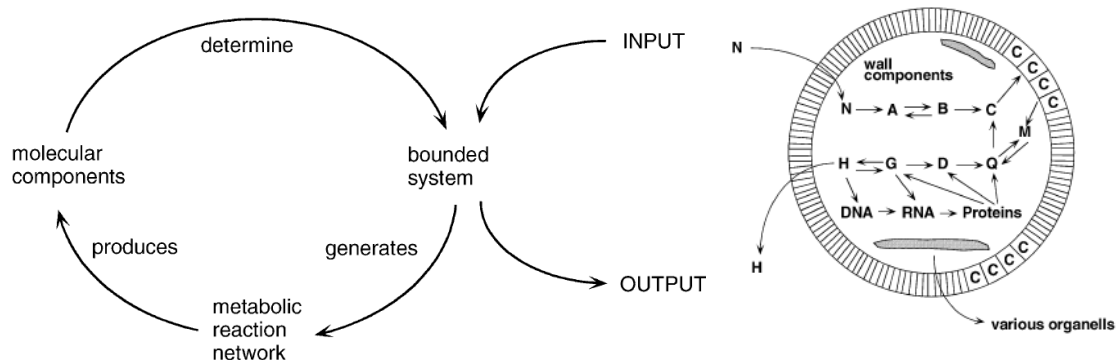


Fig.1 The chemical autopoiesis of cellular life as a self-maintaining factory. Matter and energy flow in an out of the cell, but it is *operationally closed*

To the authors great surprise, Luhmann (1984) constructed an entire field based on social autopoiesis. The idea of autopoietic systems is the theory of social systems understood as systems of communication that reproduce all their necessary, specific structures within their own self-referential closed processes. Maturana argued very vocally against the convoluted appropriation of the term, because it presupposes the autonomy of communication from actual persons. Autopoiesis only applies to networks of processes that reproduce themselves, but communications are reproduced by humans. As such, humans are merely an input to the social and not elements of it. The social system has no boundary like a cell has a membrane or a dog has skin. Again, what defines the system is its

operational closure, ie its functioning, which is in our case defined by the information architecture of the reactable community.

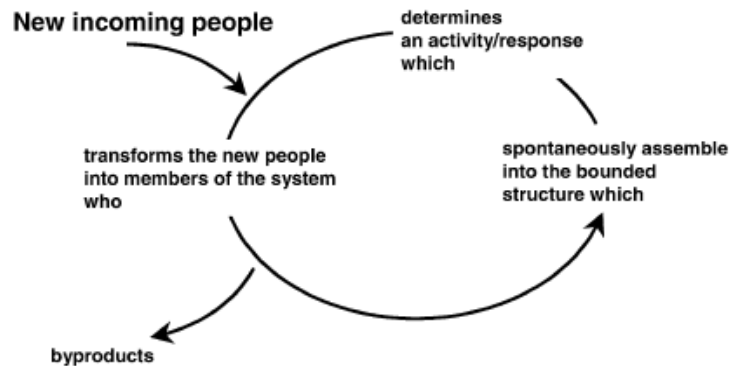


Fig.2 The autopoiesis of social systems. People provide matter and energy as input/output to the system.

Iba (2010) built an autopoietic *Creative systems* theory of creativity, based on his interpretation of Luhman's *Autopoietic systems* theory (1984) and with a clear nod to Csikszentmihalyi's influential systems approach (1999). It is based on the coupling of sociological, psychological and creative *systems*. The creative system's autopoiesis is the result of the succession of *momentary elements*, creative sparks (Sawyer 2006), that act within the boundary of the system. Each discovery is the synthesis of an idea, an association, and a finding. Ideas come from self-reference of the system, an association is made with an hetero-reference to the system's environment through a discovery media, and a finding is a new momentary element of the system. A creative spark is not necessarily *novel or useful*, but *each creative spark* participates to the autopoiesis of the creative system.

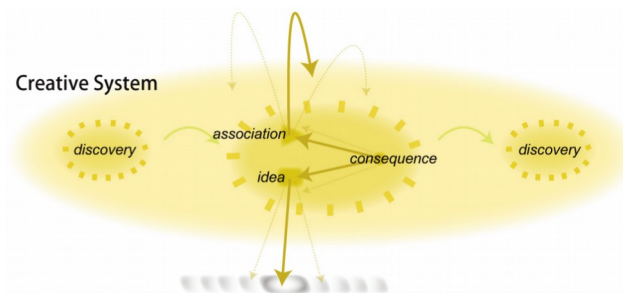


Fig.3 A discovery is constituted of an association with *a reference to the system itself*, an idea from *a reference to the system's environment*, that create a new discovery : a *consequence* (Iba 2009)

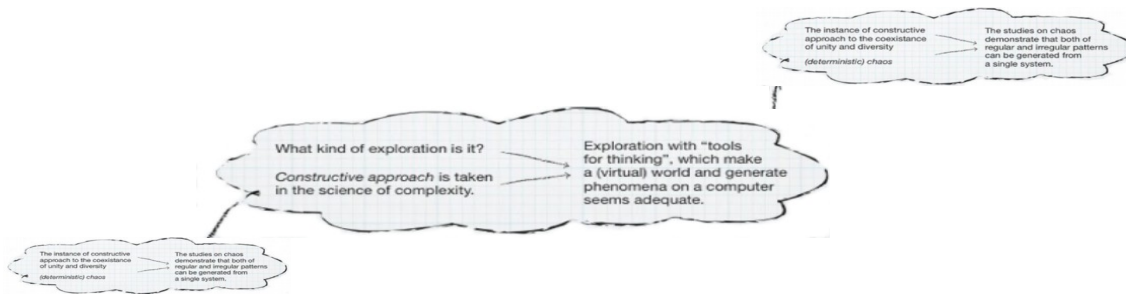


Fig.4 part of the sequence of 3 discoveries within a creative process.(Iba 2010)

Within this framework, a creative act is one that participates to the creative system, and so re-invention is also creative. Of course creativity lies on *associations* (hetero-references) with the creative system's environment, thus the need for *coupling* of psychic and social systems. Since the systems are operationally closed, the systems are inaccessible to one another. They need a *communication medium*. Iba (2010) proposes *pattern languages* as this medium.

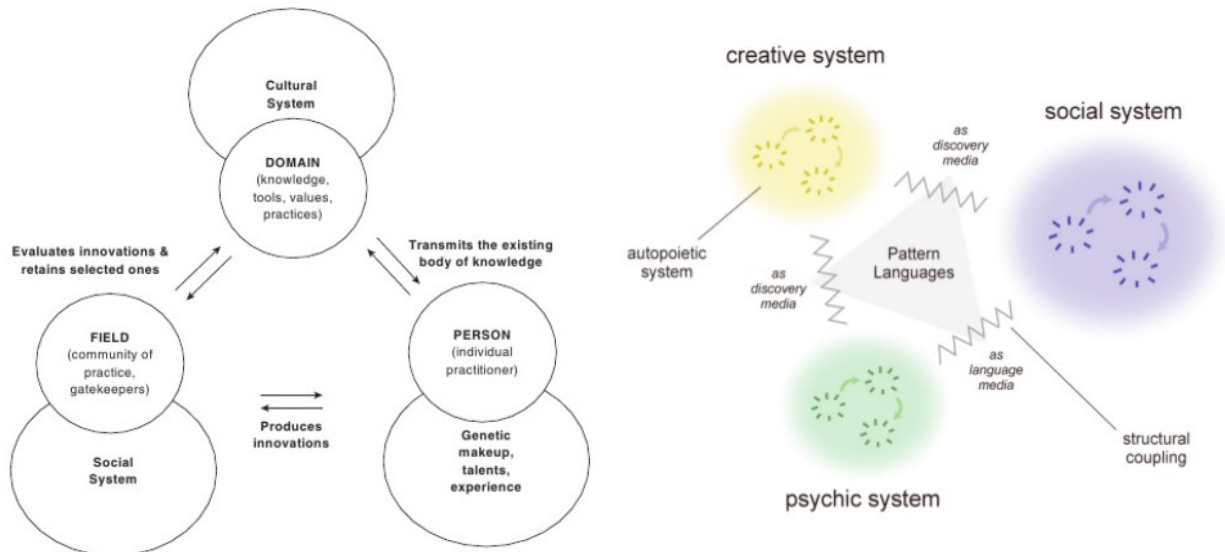


Fig. 5 The interaction of *person, field and domain*, (Csikszentmihalyi 1999) and the coupling of *psychic, creative and social systems* (Iba 2009)

Finally, the theory considers creativity not a feature of *individuals* or *society* only, but rather of the *creative system*. As long as there is creation, there is *creativity* by the creative system, but it constantly needs input (persons that make new discoveries) to maintain its autopoiesis. From now on we will refer to the psychic, social and creative systems as *person, field*, and *domain* using Csikszentmihalyi's terminology.

1.3 An introduction to the Reactable

The reacTable is a musical instrument whose design is motivated by a concept rather than a technology. Reactable *players* use *Dynamic Patching* (Kaltenbrunner et al., 2004), reminiscent of data flow programming paradigm, to connect sound generators and sound processors to flow control units or other sound processing units. It provides a predefined set of rules regarding what objects can send data to another depending on the type of the objects involved. Audio generators can't combine with one another, audio effects can be chained, and controllers can send data to any object. Using these simple metaphors, it allows for a good balance between exploration and production, and while giving considerable amount of information to collaborators, is considered to foster *group flow* (Laney et al. 2010) . At its core, it is a collaborative instrument, designed for remote or on-site collaboration (Kaltenbrunner et al., 2006). Inspired by Barbosa and Kaltenbrunner's *Public sound objects* (2002) amongst others, which allowed real-time music performance over the Internet for anyone to join, it also aimed to be an *accessible* instrument, and has been used as a subject of study with autistic children (Villafuerte, 2011) and special learning groups. Jorda's early research (1999) was exploring how the Internet, then an emerging technology, was about to challenge notions of authorship and copyright. At the time, full-duplex communication was preferred over half-duplex. Later, studies of tabletop interfaces (Jorda 2005) put emphasis on the potential for multi-user and multi-process music-making offered by digital instruments as well as on the flexibility of interface layouts and strategies of collaboration by distributing the controls (Fiebrink et al. 2009). This led to the characterization of the reacTable as a device for sharing control instead of a device for sharing data.



Fig.6 The Reactable shown to the audience of Sónar A Coruña 2010.

2. System Architecture

2.1 Reactable Mobile

Developed by the spin-off academic company, the first version of the Reactable mobile application was launched at the end of 2010. It inherits its design principles from the tabletop Reactable. In order to make music, users build patches connecting *tangibles*, the physical objects associated with signal processing units. Objects are connected to one another using drag-and-drop gestures, by putting them next to another. Then the objects parameters are modified using tap-drag gestures to emulate the rotation of the cubes, or using touch menus on the periphery of the object as in the original Reactable.

A *table* is a static definition of the objects used : their *type*, their *position*, and *parameters*. The *Dynamic Patching* algorithm determines the objects connections according to their position and types . The software can also receive sound input from the device microphone, accelerometer input, and prerecorded audio samples, all controlled through their dedicated *tangibles* shown on screen. In order to create a full song, one must *play* the instrument by changing the tangibles connections and parameters over time. A *performance* of a table can be recorded and played back by the application. Also, the app allows to record audio from a performance.



Fig.7 The reactable mobile application. Reactable Website.

2.2 The Reactable community

When the Reactable mobile app was launched, reactable and reactable mobile users were able to exchange and share their tables via the dedicated forum. Between July 2010 and March 2012, where the Reactable community website was launched, a little less than a hundred tables were exchanged, still ranking amongst the most popular today.

Reactable mobile users, once they are happy with their creation, can create a profile on the Reactable community, and upload *tables*, and related *performances*, *tracks* (song recordings) and *videos* to the platform. There, they can *download* others creations to play back and play with on their own devices, talk to one another through *comments* on uploads, and give *likes* to the ones they particularly enjoy.

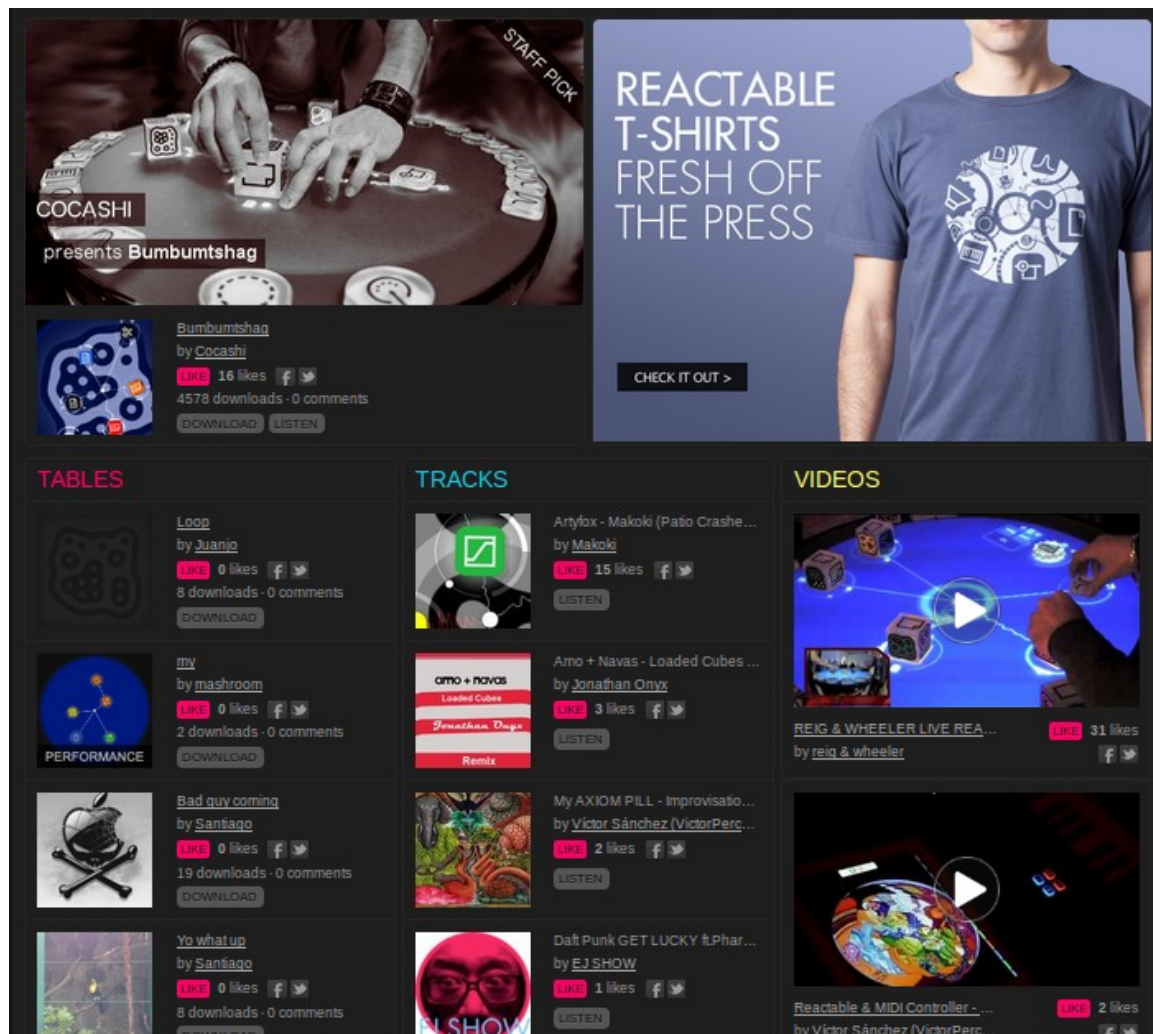


Fig 8. Screen capture of the main page of the Reactable community website.

2.3 The systems

We will now describe the functioning of the coupling of psychic, social and creative systems around the Reactable mobile application and Reactable community according to Csikszentmihalyi's (1999) systems framework.

Persons interacting with the reactable mobile application interface try to make sense of the *pattern language* it provides, actively and interactively engaging with it as a *discovery medium* for musical creation. They *produce for* and *transmit* the existing body of music, the *domain* or *creative system*, by uploading their music that can be re-enacted by the application using samples, associations between tangibles and their parameters, and performances. But their online activity and choices making music are influenced by others activity and choices, using hints from the community. The Reactable community is a *language medium* for persons to interact through *communication* (comments and online activity) with the *field* or *sociological system*, that *evaluates* tables with likes and downloads, affects their visibility and retains selected ones for the domain. As such, it is a *discovery medium* for the *creative system*, selecting the most successful memes, again using the pattern language of samples, associations between tangibles and their parameters.

- The Reactable community, through comments and online behavior, is a language medium for persons to interact with the field
- The Reactable mobile application, by means of audio files, tangibles, parameters, and gestures, is a discovery medium for the domain to interact with the persons.
- The Reactable community, by selecting tables based on success according to likes and downloads, is also a discovery medium, for the field to interact with the domain.

2.4 Data Retrieval

The data we will be studying first came in two separate bulks. We are using a dump from the SQL database of the Reactable community website from June 11th, 2013 and a collection of all the tables uploaded to the platform as zip files.

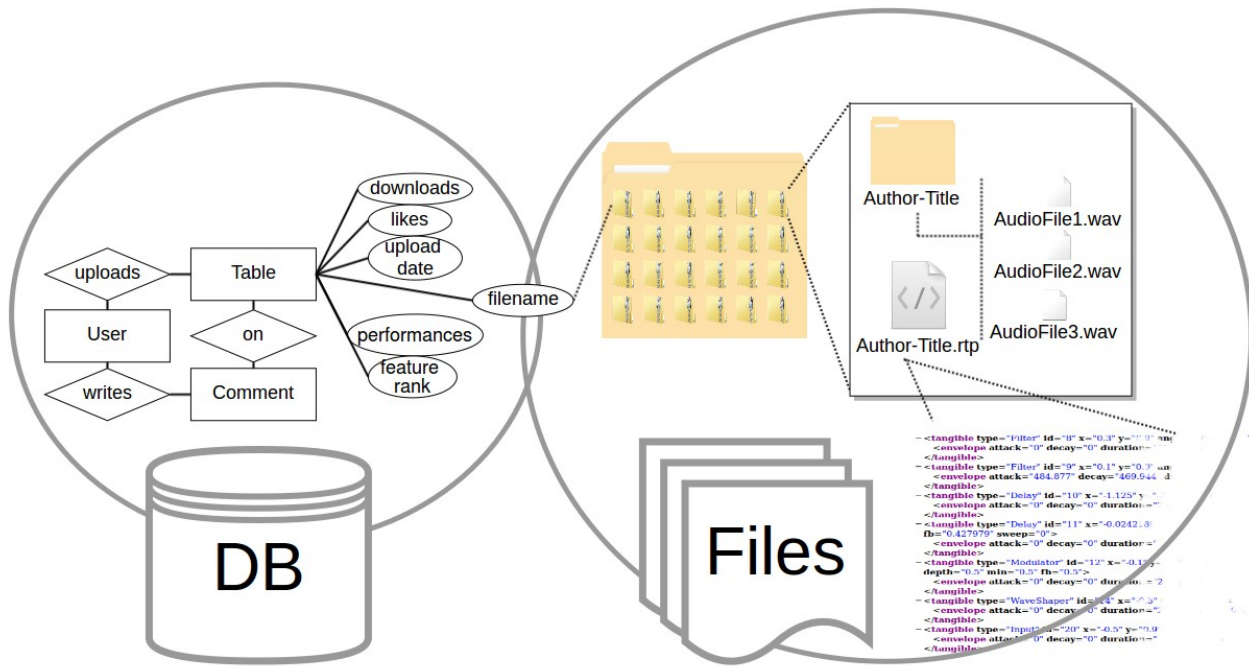


Fig. 9 Data used for the analyses

The database contains information about users, their tables, songs, videos, links to their social networks, comments they left, likes they gave and so on. As of June 11th, the Reactable community has 14293 registered users. The second part is a 22GB folder containing all 3169 tables packaged as zip files. Those packages contain information about the *tangibles* used and their parameters in the XML format (.rtp file), the *samples* used (.wav files), and a transcription of a performance (.rtperf file) if one was recorded. They define the standard data format that is used to exchange one's creation (.rtz files). In order to study correlations between the aforementioned systems, we needed a unified data model. We then created 2 new data models, *samples* and *tangibles*, in which we store information about what objects and what samples were used.

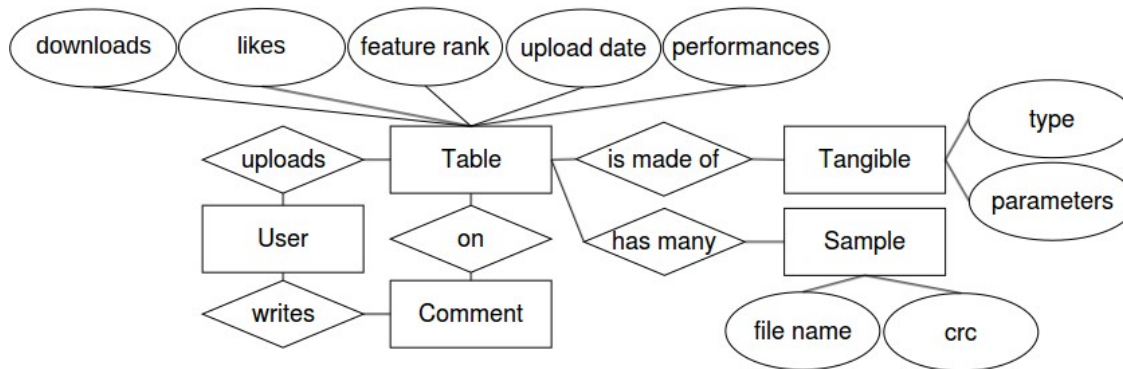


Fig.10 The unified data model, with its most relevant attributes

A Ruby on Rails application was built for this purpose : in order to retrieve data in a format exploitable by SPSS, a new field was added to existing tables, and a Rails query corresponding to the variable to retrieve was created. For instance, in order to be able to calculate the correlation between elaboration and likes, the field “defaults” was added to the table “tangibles”, and a Rails function parsed the zip file for each table to count the ratio of default values for its parameters. Once the “defaults” field for each tangible is filled, a simple SQL query can return comma separated values (.csv file) for the number of likes a table received and the ratio of defaults parameters it has. The ruby code for the operations performed can be found in appendix b)

2.5 Preliminary analysis

We will go here through basic statistics to give a glimpse of what is going on in the Reactable community.

a) Field interacting with persons

Quite few comments are exchanged on the platform. 97% of registered users never wrote any comment, and 38% of these comments were made on one's own table. Very few comments were written about tables uploaded on the forum. When the Reactable community was launched, a contest was organized to kickstart it, and an unprecedented peak in activity was recorded. The contest, organized between June and July 2012 offered a Reactable live! instrument (the tabletop version of Reactable), after the 20 tables with most likes were judged by a jury of musicians with international fame, based on their creativity and skills. Unfortunately, they had to deal with cheating from many users creating fake accounts to get more likes, which was facilitated by the fact likes only have a receiver, not a giver. A general feeling of mistrust between members of the community seemed to appear. Still, the winners showed skill and creativity using the application and received almost unanimous positive feedback from the community.

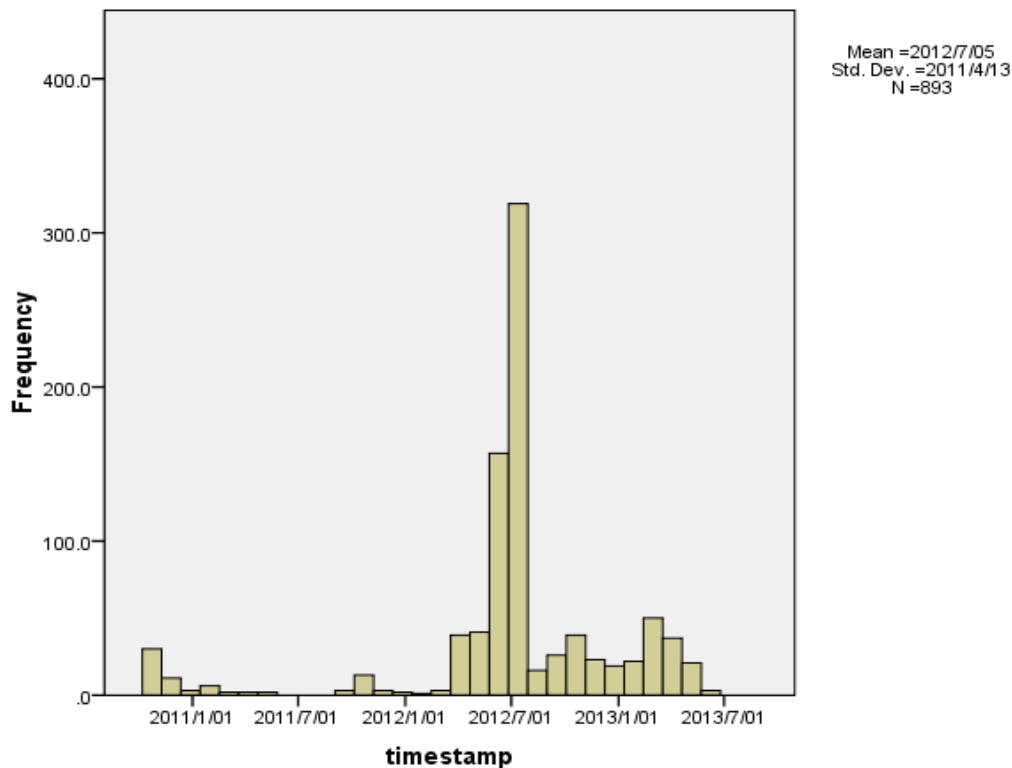


Fig.11 Number of comments on the platform over time. Comments written before March 2012 come from the Reactable forum, that was replaced then by the Reactable Community

b) Domain interacting with persons

There is a steady, heavy flow of tables shared and downloaded on the platform, which gives the user a considerable amount of creations to get inspired from. Since its inception, tables were downloaded more than 1640000 times, which is an average of 518 downloads per table. Nonetheless, the distribution of downloads is extremely skewed: 88% of the tables received less than 518 downloads, which means a minority of tables is likely to have a disproportionate influence on other users. Downloads are mostly “blind” : very few tables (6,7%) are uploaded along with an audio recording, so users most of the time users don't have the possibility to listen to a table before it is loaded in the application. And since most tables are uploaded without a performance (70%), the static structure of tables ie the objects and samples used, their parameters and how they are connected is more immediately accessible than how the table can or is meant to be played. Table reuse is considerable : 19% of the tables uploaded were created from downloading and modifying another table, and reuse count goes up to 5 successive “sparks”. Looking for samples is likely to be an important drive for downloads. Tables usually make a heavy use of the *loop* tangible, and so far 16800 samples are used in all the tables, many of which are actually the same audio file. We estimated the number of distinct samples used on the platform to 3900, which means every audio file is on average used 4 times. Out of the 80% tables that use samples, only 20% are not using samples taken from another table. Samples are then the most used discovery medium for individuals' psychological systems. But it is completely

independent from creative use of the pattern language of tangibles, because, unless the same table is reused, a sample from another table is generally accessed from a browser that only references the original table by its name. This way, the user is unable to build on top of previous work, and given an incentive to reuse the sample “as is”, instead of finding a new or creative use for it.

c) Domain interacting with field

As stated before, users and tables are given visibility according to the downloads and likes they received, and whether they were featured by Reactable to showcase the possibilities offered by the application. To discover new material from the community, users need to browse through the following categories, ordered by the following criteria (colored is default).

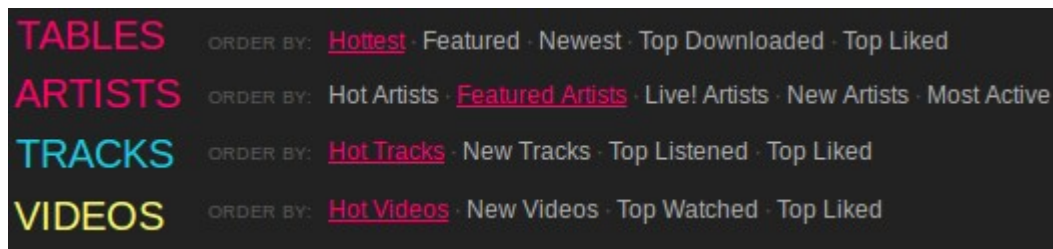


Fig. 12 Search filters for browsing tables, artists, tracks and videos on the platform

For all elements, “Hot” is calculated as a combination of likes and downloads from tables of the last 2 weeks. In order to find new interesting material and contribute to the ongoing autopoiesis of the creative system, users need to skim through pages of new songs either trusting the “Hot” algorithm, or downloading new tables and hoping to find something interesting. Remixing, while possibly driving the activity of the community, are not credited publicly, although appearing in the rtp file. Same goes for sample reuse. As such, creative activity is not directly a discovery medium for the domain, but mostly through the “self-fulfilling prophecies” of downloads and likes which, although not completely unrelated to creativity, is mediated by a process that doesn't allow for a great *generative* capacity. No proper community effort is driving the creative system, meaning, it is not through selection and contribution that tables get passed along, but through an algorithm that reflects *appreciation* and *newness* of finished work that emphasizes the individual's supposedly eminent personality. While persons conducting creative processes can be creative in this context, our argument is that the most creative persons (ie, whose contribution to the domain is most important) won't actually be those relying most on (internal) creative processes.

3. Methods

3.1 Objectives and hypothesis

According to the previous observations, we assimilate the creative behavior of Reactable community to be mostly that of “egoboosters” (Iba et al. 2009). The information architecture and flows of information it supports is the evidence. Since there is “social creativity” as long as there is creation to be evaluated and transmitted through a field, our objective is to prove that in this context it does not need “psychological creativity”, because creative activity keeps feeding the domain with the energy of newcomers spontaneously acting according to the following paradigm “upload, get downloads by people who didn't listen to your music, try to get as many downloads as possible, and disappear until you upload a new table”. Our hypothesis is then that :

H. People that rely on table reuse are potentially more creative in the sense that they contribute more to the domain

3.2 Operationalization of the variables

a) Originality

The originality of a person's production will be evaluated on the basis of the originality of the objects it is using on a table. Each table will then be assigned an originality score, calculated by the following formula :

originality = for each tangible in table, sum(count of occurrences of tangible in database)/number of tangibles in table.

The statistical rareness of a tangibles was established by counting every single occurrence of the (object type, object subtype) pair. For instance, using a “Loop” object with the “loop” subtype is extremely common, but using the “Loop” object with the “oneshot” subtype is very rare.

Object type	subtype	count
Loop	loop	10849
Delay	feedback	2065
Sequencer	tenori	1830
Filter	lowpass	1673
Sequencer	sequencer	1628
Oscillator	oscillator	1358
Sampleplay	synth	1356
Sampleplay	drum	987
Tempo	tempo	882
WaveShaper	distort	873
Modulator	ringmod	613
Delay	pingpong	588
Lfo	sine	565
Volume	volume	447
Tonalizer	tonalizer	442
Sequencer	random	360
WaveShaper	compress	334
Filter	bandpass	329
Accelerometer	accelerometer	288
Delay	reverb	284
Filter	hipass	280
Modulator	flanger	265
Loop	oneshot	224
Modulator	chorus	196
WaveShaper	resample	132
Lfo	noise	125
Input	input	103
Lfo	saw	73
Lfo	square	72
Volume	reverb	46
Volume	compressor	34

Fig. 13 Frequency distribution of every tangible type and subtype combination

b) Elaboration

The elaboration of a table will be measured looking at how many parameters were tweaked for each object. Every parameter of an object that is different from the default for that object will be counted, then divided by the total number of parameters for that object.

elaboration = number of tweaked parameters / total number of parameters available for chosen objects

Object type	parameters
Volume	compression_level, reverb_level, reverb_input, reverb_on, delay_fb, delay_time
Tempo	tempo, meter, swing
Accelerometer	amp_mult, freq_mult, freq, duration
Lfo	freq_mult, samplehold
Sequencer	autoseq_on, noteedit_on, duration, num_tracks, offset
Delay	delay, fb, sweep, envelope
Modulator	effect, drywet, depth, min, fb, envelope
WaveShaper	effect, drywet, envelope
Input	envelope
Oscillator	sweep, current_osc, second_tonalize, second_amp1, offset1, detune1, second_amp2, offset2, detune2, wave2, bite, envelope
Loop	envelope

Fig. 14 Every parameter taken into account, by object type

Parameters taken into account include parameters accessible by rotating the tangible (except for filter and input), parameters only accessible via tangible menu, and envelope as one single parameter. Parameters not taken into account include sequencer object sequences, tonalizer object scales and sampleplay object instruments, and if the oscillator tangible wave was hand-drawn.

The elaboration score of a user will be the average elaboration score of its tables. Following is a frequency distribution of the ratio of default settings per table giving an overview of the uses of the community.

c) Divergent thinking score

Divergent thinking is calculated as an average of elaboration and originality.

Divergent thinking score = (Elaboration score + Originality score) / 2

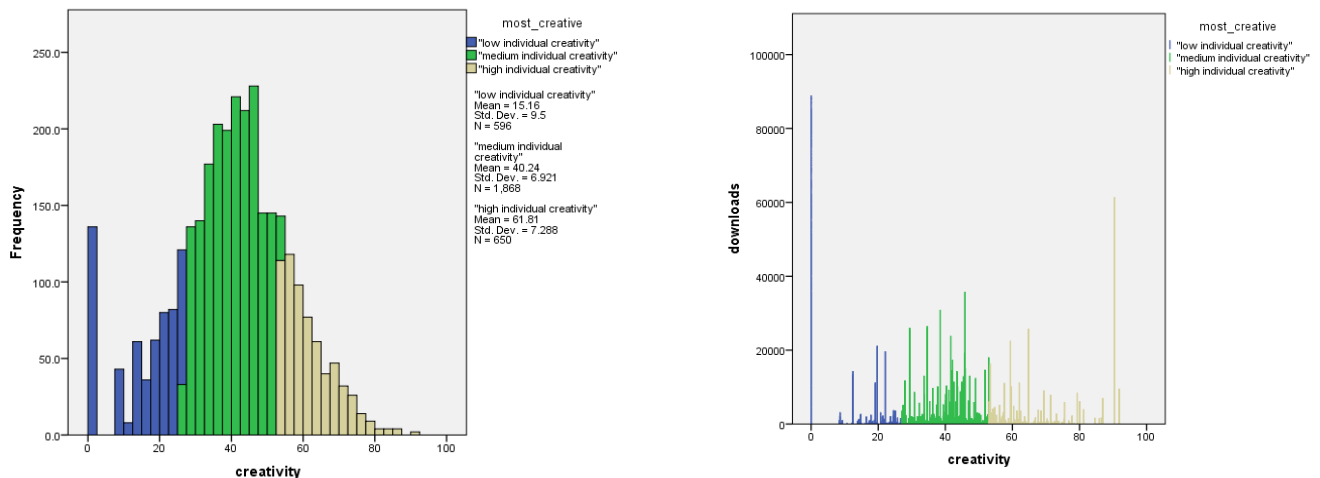


Fig. 15 p-creativity score with 20-60-80% cumulative frequencies. Medium p-creativity gets most downloads, but the distribution of downloads over creativity doesn't allow for significant comparison of medians across groups.

d) Confounding variables

Various parameters might get undesirable side effects and ought to be discarded. Because we are studying the community, tables originating from the forum (created prior to April 2012) will not be taken into account. Accordingly, tables that participated in the contest that kickstarted the community will be discarded. Featured tables will also be reserved a separate treatment, being in a special position given by the company.

Another possible confounding factor when looking at downloads is time. The older a table is, the more likely it is to have received more downloads. Nonetheless, after two weeks, tables cease to appear as “hot”, and time should be a lot less relevant factor. Unfortunately, an analysis of how downloads normally evolve over time is not possible unless several database dumps are used

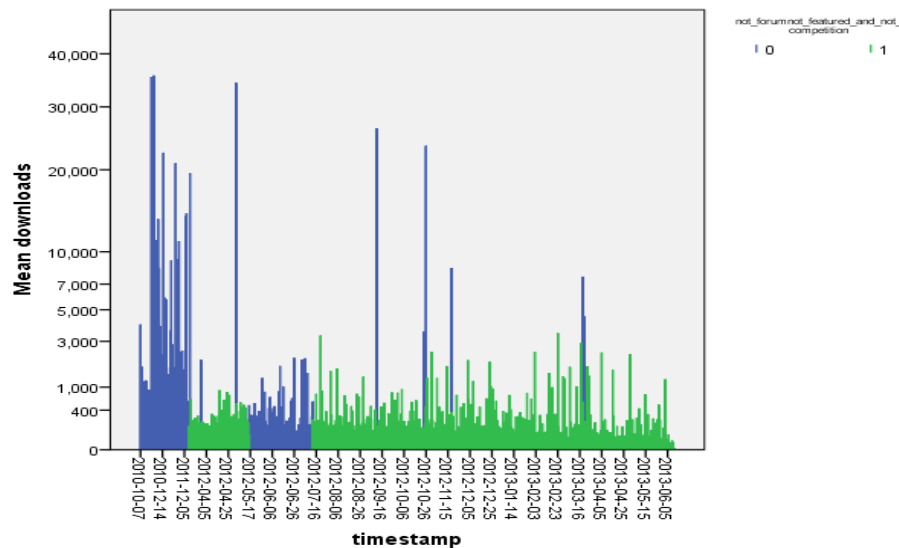


Fig.16 Mean downloads by upload date. Green data is regular uploads, blue is for forum, competition and featured users

4. Results

We compared the creativity score computed as an average of originality and elaboration scores. None of the computed scores followed a normal distribution, so non-parametric tests were used.

H. People that rely on table reuse are potentially more creative in the sense that they contribute more to the domain

While reuse of tables is unrelated to divergent thinking score, tables that come from other tables tend to be more appreciated and to spread more than those that don't. See appendix a) for detail on tests.

A Mann-Whitney U test was run to determine if there were differences in divergeng thinking score between tables relying on reuse and those that don't. Distributions of the divergent thinking score were similar, as assessed by visual inspection. Median divergent thinking scores for reuse were not statistically significantly different, $U = 702,830$; $z = -.791$; $p = .429$

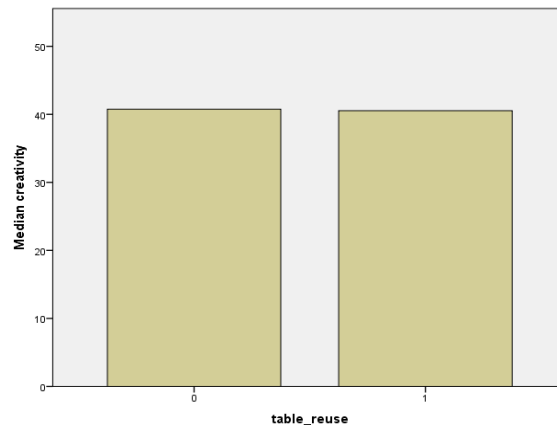


Fig.17 Comparison of median p-creativity score across reuse groups

A Mann-Whitney U test was run to determine if there were differences in appreciation between tables relying on reuse and those that don't. Distributions of the appreciation score were similar, as assessed by visual inspection. Median appreciation for reuse (0.044298) and original(0.0027624) scores were significantly different, $U = 16,940$; $z=1.726$; $p = 0.084$

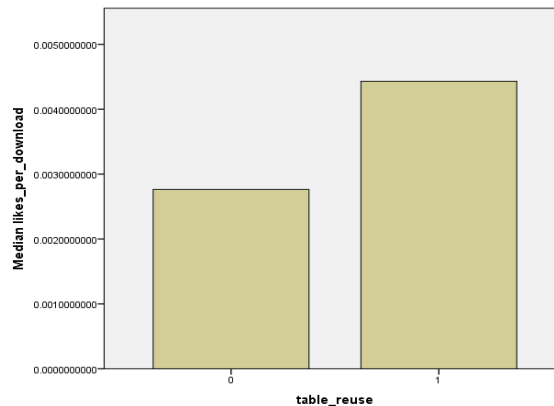


Fig.18 Median likes per download across reuse groups.

A Mann-Whitney U test was run to determine if there were differences in spread between tables relying on reuse and those that don't. Distributions of the downloads were similar, as assessed by visual inspection. Median downloads for reuse (119) and original (108) scores were significantly different, $U = 770,307$; $z=1.571$; $p = .116$

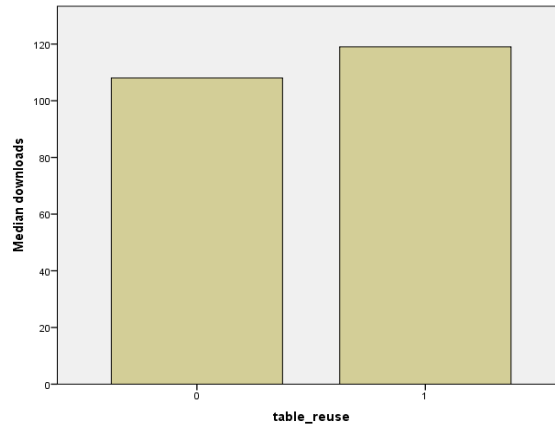


Fig.19 Median downloads across table_reuse groups

5. Discussion and conclusion

The results found are encouraging. We might have expected superior divergent thinking score for tables coming from several iterations since possibly more options are explored when several persons are involved in the creation. The results matched our hypothesis : tables that came from other tables receive significantly more likes per download, even given that those same tables receive more downloads. This is the sign of a superior recognition of the appropriateness of the production when several people are involved, and thus of a superior creativity, that can not be explained only by the sum of the individual creativities involved. Unless tables that have ascent were put forward by featuring, exposure from the forum or from the competition, which should be verified, the table that rely on reuse are genuinely creative : they contribute to the domain (they are spread) relying more than other tables to appreciation from their peers than on the self-fulfilling prophecy of downloads. Everything happens as if reusing a table, successive users were successfully leaving a *cognitive trace* in the domain, which made somehow the table more valuable in a way that can't be measured by p-creativity. Unfortunately it is not possible to know what chain of tables were involved in the reuse. It seems, according to figure 15 that tables with average creativity get the most downloads. At least that's what the distribution seems to look like. If that is so, then once again this is remarkable because the superior amount of downloads can not be explained by individuals creative ability. Many additional factors should be taken into account and their influence carefully studied. The amount of data available allows for many factors individual and interactional influence to be studied. Whether one or several performances were uploaded, audio files,

It is remarkably useful that reactable tables can only be downloaded, evaluated and shared *by reactable mobile users*, because it maintains the *operational closure* of the system. Nobody outside the system can participate in the inner working of the system, except of course the systems designers. By changing the community architecture from a user or conversation-centered (Community of Practice) community to a *content-centered* (OCOC), the information architects at Reactable systems changed the chain of functional activity that feeds the community. Reactable forum users are significantly more divergent thinking types. It is assumed that this is because, as 'beta' users they are most likely to be experienced and then more proactive, as opposed to novice users that rely more on their impression of what others do. But these users interacted using a *forum*, which is arguably more adapted to *open-source communities*.

Difficulties and future work.

The artifact around 0% creativity is due to the algorithm chosen. Coincidentally, ordinary objects as loops only have 1 parameter, so tables using only this type of object get polarized score. Some extra parameters should be added to smooth out the distribution of p-creativity and so also allow for comparing groups across the distribution. A *flexibility* criteria should be added, and the p-creativity criteria should be then an attribute of *users* instead of *tables*. This should allow to unveil more creativity patterns easily. The influence of the presence of *performances*, *artworks*, or *tracks* associated to tables could be studied.

It is important in our opinion to stress the fact that the present study is actually quite agnostic regarding musical practice. We are not really, or at least not directly looking at musical creativity. At no point any assumption was made about the musicality of the productions made. As a study on pattern languages, the approach used could really well be adopted for very distinct domains. Then, of course, the creativity is not in the objects used, but in their *dynamic associations* over time. We started exploring the possibility of looking at what connections were made through hardlinks, but the amount of missing data is simply too high for the data to be significant. The complexity of the *dynamic patching* algorithm did not allow it to be replicated for the purpose of our study, but

we envision exciting possibilities for creativity studies where statistics are made about what different kind of dynamic associations are made between objects, to assess the *exploration and transformation of conceptual spaces*. On a more distributed creativity focus, we would like to hope for the possibility of using *network dynamics* studies for creativity, not merely linking *users* as is usually made when studying platforms such as wikipedia, but literally linking *ideas*, and observe the unfolding of the autopoiesis of the creative system through observable distributed creative practices that can be enacted by the design of the appropriate system.

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Appendix

a) Result tables

Hypothesis Test Summary

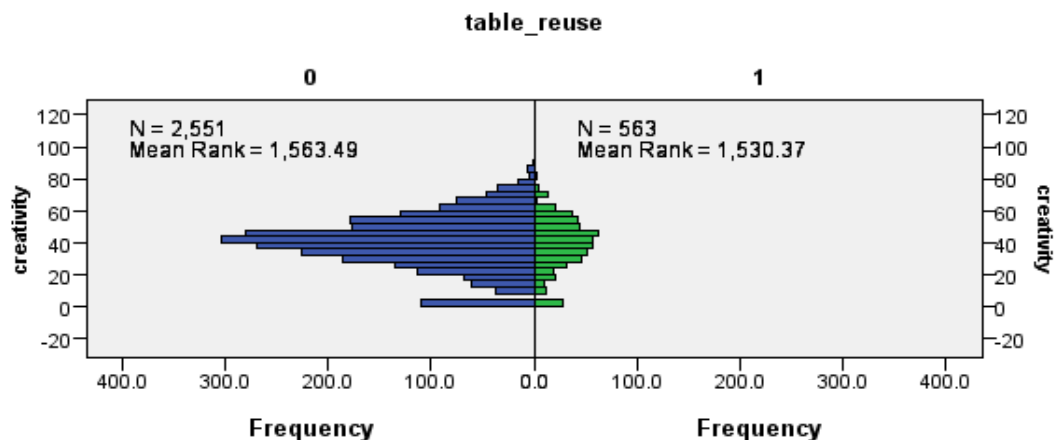
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of creativity is the same across categories of table_reuse.	Independent-Samples Mann-Whitney U Test	.429	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

	Null Hypothesis	Test	Sig.	Decision
1	The medians of creativity are the same across categories of table_reuse.	Independent-Samples Median Test	.780	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Independent-Samples Mann-Whitney U Test



Total N	3,114
Mann-Whitney U	702,830.000
Wilcoxon W	861,596.000
Test Statistic	702,830.000
Standard Error	19,307.659
Standardized Test Statistic	-.791
Asymptotic Sig. (2-sided test)	.429

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of likes_per_download is the same across categories of table_reuse.	Independent-Samples Mann-Whitney U Test	.084	Retain the null hypothesis.

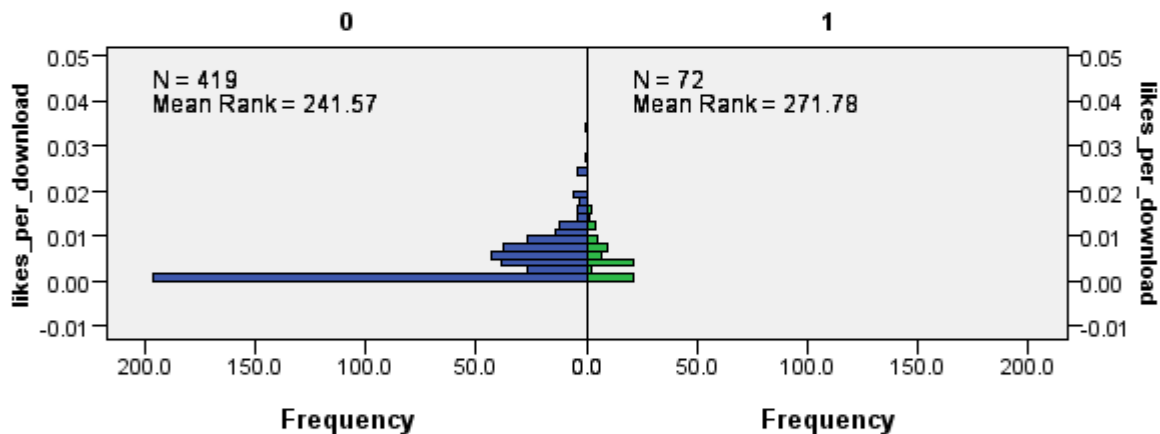
Asymptotic significances are displayed. The significance level is .05.

	Null Hypothesis	Test	Sig.	Decision
1	The medians of likes_per_download are the same across categories of table_reuse.	Independent-Samples Median Test	.001	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Independent-Samples Mann-Whitney U Test

table_reuse



Total N	491
Mann-Whitney U	16,940.000
Wilcoxon W	19,568.000
Test Statistic	16,940.000
Standard Error	1,075.069
Standardized Test Statistic	1.726
Asymptotic Sig. (2-sided test)	.084

Hypothesis Test Summary

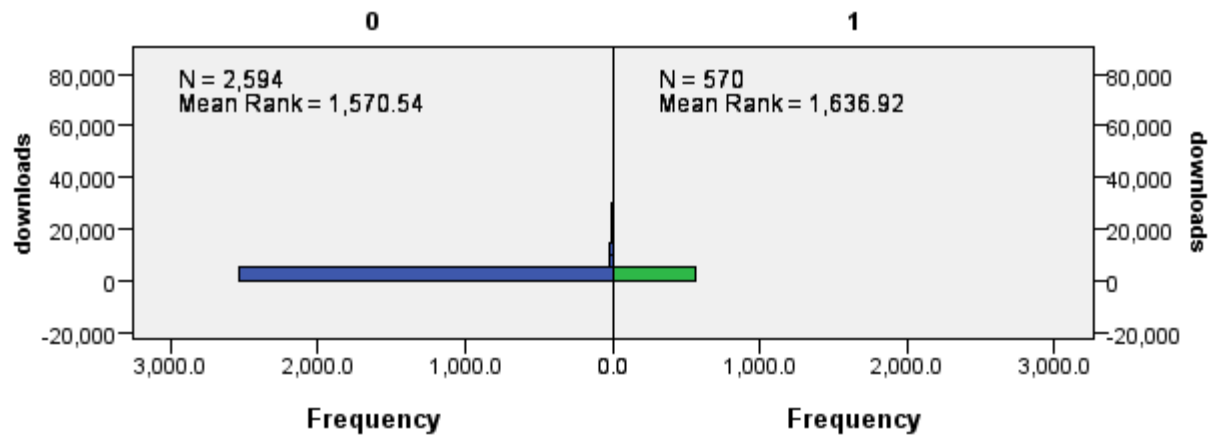
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of downloads is the same across categories of table_reuse.	Independent-Samples Mann-Whitney U Test	.116	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

	Null Hypothesis	Test	Sig.	Decision
1	The medians of downloads are the same across categories of table_reuse.	Independent-Samples Median Test	.015	Reject the null hypothesis.

Independent-Samples Mann-Whitney U Test

table_reuse



Total N	3,164
Mann-Whitney U	770,307.500
Wilcoxon W	933,042.500
Test Statistic	770,307.500
Standard Error	19,747.603
Standardized Test Statistic	1.571
Asymptotic Sig. (2-sided test)	.116

b) Rails application for retrieving data and computing creativity scores

the following function parses zip files to store information on tangibles. It is given to clarify the algorithm used to perform the computation

```
def get_tangibles

  uploads_path = "/home/polpo/reactable/June11db/uploads/"

  files = p Dir.entries(uploads_path).sort!.map{|f| (f.split(".").second.nil?)?
f:f.split('._').second}

  files.each do |f|

    table = nil

    zip_file = nil

    if f.split(".").last == "rtz"

      begin

        zip_file = Zip::ZipFile.open uploads_path + f #open it

        table = Table.find_by_reactable_file f

      rescue

      end

      if zip_file && table

        zip_file.each_entry do |e|

          if e.name.split('.').last == "rtp" #look for rtp file

            begin

              xml = Nokogiri::XML(e.get_input_stream.read) #returns a nokogiri-
parsable stream

              result = xml.xpath("//tangible") #get tangible nodes

              create_tangibles result, table

              break

            rescue

            end

          end

        end

      end

    end

  end

end
```

```

        end

    end

end

end

end

```

This function creates a new entry for given a nokogiri query result, and the corresponding table

```

def create_tangibles (result, table)

  default_settings={:Volume=>{:compression_level=>"0", :reverb_level=>"0",
:reverb_input=>"0", :reverb_on=>"0", :delay_fb=>"0", :delay_time=>"0.7"},

                  :Tempo=>{:tempo=>"128", :meter=>"4", :swing=>"0"},

                  :Accelerometer=>{:amp_mult=>"1", :freq_mult=>"1",
:freq=>"12", :duration=> "0.75"},

                  :LFO=>{:freq=>"5", :mult=>"0", :samplehold=>"1"},

                  :Sequencer=>{:autoseq_on=>"0", :noteedit_on=>"0",
:duration=>"0.75", :num_tracks=>"6", :offset=>"0"},

                  :Delay=>{:delay=>"0.66", :fb=>"0.5", :sweep=>"0"},

                  :Modulator=>{:effect=>"0.5", :drywet=>"0.5",
:depth=>"0.5", :min=>"0.5", :fb=>"0.5"},

                  :WaveShaper=>{:effect=>"0.5", :drywet=>"0.5"},

                  :Input=>{:amp=>"0"},

                  :Oscillator=>{:sweep=>"0", :current_osc=>"0",
:second_tonalize=>"0", :second_amp1=>"0", :offset1=>"0", :detune1=>"0",
:wave1=>"0", :second_amp2=>"0", :offset2=>"0", :detune2=>"0", :wave2=>"0",
:bite=>"0"},

  }

  result.each do |r| #for each tangible node, create tangibles and store
hardlinks

    node_type = r.xpath('@type').to_s

    locals = String.new

    #hardlinks = Array.new

    if node_type != "Output" && r.xpath('@docked').to_s != '1' #if not an output

```



```

and not docked

    defaults = 0

    if default_settings.has_key? node_type.to_sym

        default_settings[node_type.to_sym].each do |s|

            if (r.xpath("@"+s[0].to_s).to_s == s[1]) #test whether s corresponds to
a default value

                defaults+=1

            end

        end

    end

    defaults = default_envelope r, defaults

    if (Tangible.find_by_local_and_table_id r.xpath('@id').to_s,
table.id).nil?

        t=Tangible.create(:tangible_type => node_type, :subtype =>
r.xpath('@subtype').to_s, :table_id => table.id, :defaults => defaults, :local =>
r.xpath('@id').to_s)

        end

        r.xpath("//tangible[@id="+t.local.to_s+"/*[@to>-1]").each do |h|

            locals+=h.xpath("@to").to_s+", "

        end

        # hardlinks[t.id.to_s.to_sym] = locals[0..locals.length-2] unless
locals.empty? #gives association between tangible id and locals hardlinked to

        locals.clear

    end

end

=begin    if !hardlinks.empty?

        hardlinks.each do |h| #find by

            Tangible.find(h[0]).update_attribute :hardlink_to, h[1].split(",").map{|l|
Tangible.find_by_local_and_table_id(l, table.id).id}.join(",")

        end

        hardlinks.clear #clear values for current rtp

```

```

end

=end

end

```

The following function tests whether the envelope used for the current object is the default for that object

```

def default_envelope (r, defaults)

  default_envelopes = {

    :default => {:attack=>"0", :decay=>"0", :duration=>"25",
:points_x=>"0,0,0,0.2,1", :points_y=>"0,1,1,1,0", :release=>"20"},

    :filter_8 => {:attack=>"0", :decay=>"0", :duration=>"0",
:points_x=>"0,0,0,1,1", :points_y=>"0,1,0.5,0.5,0", :release=>"0"},

    :filter_9 => {:attack=>"484.877",
:decay=>"469.944",:duration=>"1193", :points_x=>"0,0.406256,0.8,1,1",
:points_y=>"0,1,0.5,0.5,0", :release=>"0"},

    :oscillator_47 => {:attack=>"0", :decay=>"500", :duration=>"600",
:points_x=>"0,0,0.8,1,1", :points_y=>"0,1,0,0,0", :release=>"0"}

  }

  if ["10", "11", "12", "14", "20", "24", "29", "34", "39",
"46"].include? r.xpath("@id").to_s

    default_envelopes[:default].each do |e|

      if (r.xpath("//tangible[@id =" + r.xpath("@id").to_s +
"]/envelope")).xpath("@"+e[0].to_s).to_s != e[1]

        return defaults #if found a value different from defaults, return
defaults count unchanged

      end

    end

    return defaults + 1 #if all values are default, increment defaults
count by one

  elsif (r.xpath '@id').to_s == "8"

    default_envelopes[:filter_8].each do |e|

      if (r.xpath("//tangible[@id =" + r.xpath("@id").to_s +

```

```

    "]/envelope")).xpath("@"+e[0].to_s).to_s != e[1]

        return defaults

    end

end

    return defaults + 1 #if all values are default, increment defaults
count by one

    elsif (r.xpath '@id').to_s == "9"

        default_envelopes[:filter_9].each do |e|

            if (r.xpath("//tangible[@id =" + r.xpath("@id").to_s +
    "]/envelope")).xpath("@"+e[0].to_s).to_s != e[1]

                return defaults

            end

        end

        return defaults + 1 #if all values are default, increment defaults
count by one

    elsif (r.xpath '@id').to_s == "47"

        default_envelopes[:oscillator_47].each do |e|

            if (r.xpath("//tangible[@id =" + r.xpath("@id").to_s +
    "]/envelope")).xpath("@"+e[0].to_s).to_s != e[1]

                return defaults

            end

        end

        return defaults + 1 #if all values are default, increment defaults
count by one

    else #if object none of those with envelope settings, return defaults
count as is

        return defaults

    end

end

```

This function computes the elaboration score for a table (at this stage it is a defaults_ratio, so, it's an *unelaboration* score)

```
def compute_defaults_ratio

  default_settings={:Volume=>6,

                   :Tempo=>3,

                   :Accelerometer=>4,

                   :LFO=>3,

                   :Sequencer=>5,

                   :Delay=>4,

                   :Modulator=>6,

                   :WaveShaper=>3,

                   :Oscillator=>13,

                   :Filter=>1,

                   :Loop=>1,

                   :Input=>1

  }

  #no sampleplay, no tonalizer, which means

  Table.all.each do |t|

    defaults=0

    params=0

    t.tangibles.each do |ta|

      if !(default_settings[ta.tangible_type.to_s.to_sym]).nil? #if the
tangible is part of those studied

        params+=default_settings[ta.tangible_type.to_s.to_sym] #count how many
parameters could have been tweaked

        defaults+=ta.defaults #count how many parameters were tweaked

      end

    end

  end

end
```

```

    if params != 0
      t.update_attribute(:defaults_ratio, defaults.to_f/params.to_f)
    end

  end

end

end

```

This function calculates the originality score of tables. At this stage, it is not a ratio since it doesn't take into account the possible scores, so it is merely an originality *score*

```

def originality #computes originality
  type_subtype_probability = {
    :Volume_compressor=>34,
    :Volume_reverb=>46,
    :LFO_square=>72,
    :LFO_saw=>73,
    :Input_input=>103,
    :LFO_noise=>125,
    :WaveShaper_resample=>132,
    :Modulator_chorus=>196,
    :Loop_oneshot=>224,
    :Modulator_flanger=>265,
    :Filter_hipass=>280,
    :Delay_reverb=>284,
    :Accelerometer_accelerometer=>288,
    :Filter_bandpass=>329,
    :WaveShaper_compress=>334,

```

```

:Sequencer_random=>360,
:Tonalizer_tonalizer=>442,
:Volume_volume=>447,
:LFO_sine=>565,
:Delay_pingpong=>588,
:Modulator_ringmod=>613,
:WaveShaper_distort=>873,
:Tempo_tempo=>882,
:Sampleplay_drum=>987,
:Sampleplay_synth=>1356,
:Oscillator_oscillator=>1358,
:Sequencer_sequencer=>1628,
:Filter_lowpass=>1673,
:Sequencer_tenori=>1830,
:Delay_feedback=>2065,
:Loop_loop=>10849
}

=begin
  probability of tenori = 1362 / 21270
  probability of loop = 7996/21270

  overall originality = 1 - probability of tenori + 1 - probability of loop
  = t.tangibles.count*(1-(type_probability[tenori]+type_probability[loop])/21270)
=end

#total = 21270
Table.all.each do |t|

```

```

probability = 0.0
tangibles_count = 0
t.tangibles.each do |ta|
  if ta.tangible_type == "Oscillator"
    probability += 1358
    tangibles_count +=1
  else
    probability += type_subtype_probability[[ta.tangible_type,
ta.subtype].join("_").to_sym]
    tangibles_count +=1
  end
end
if probability > 0
  t.update_attribute(:originality, probability/tangibles_count)
end
end
end

```

This function computes the originality score for all tables

```

def compute_creativity
  Table.all.each do |t|
    #creativity = ((1 - defaults_ratio) + ((max unoriginality -
unoriginality)*100/(max unoriginality - min unoriginality))/2
    begin
      t.update_attribute :creativity, (((1-t.defaults_ratio)*100) + ((10849 -
t.originality)*100/10701))/2
    rescue
    end
  end
end

```

end
end