

## **Supplementary data for “Methodological diversity and theoretical integration: research in design fixation as an example of fixation in research design?”**

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This document accompanies two files which provide supplementary data for the above article. Both files are in Comma-Separated Values (CSV) format, listing the nodes and edges for a citation map.

The citation map was generated by defining individual academic texts as nodes and citations between those texts as edges in a directed network. The sample of experimental design fixation texts was defined as the overlap in the core texts addressed in recent reviews by Vasconcelos and Crilly (2016, p. 6) and by Sio et al (2015, supplementary data). This yielded 26 unique journal articles (conference proceedings were omitted). The sample of qualitative studies related to design fixation (typically reports on design practice in professional contexts, with reference to fixation, creativity, inspiration and precedent) was identified by combining the core texts addressed in recent reviews by Crilly (2005; 2019). This yielded 31 texts (all publication formats were included). Each text in the corpus of 57 texts was defined as a node with the node type (indicated by colour) defined by the research method. Each citation link between texts in the network was defined as an edge (directed from citing text to cited text). A citation link between texts was defined as one edge, no matter how many times one text cited the other (due to the small dataset, the ‘direct citation’ method was used, see Boyack & Klavans, 2010). All nodes with a degree less than two were filtered out and the node size was scaled with in-degree rank. The resulting collection of nodes and edges was drawn as a network graph using ‘Gephi’ v0.9.2 (Bastian, Heymann, & Jacomy, 2009), employing the layout algorithm ‘Force Atlas 2’ (Jacomy, Venturini, Heymann, & Bastian, 2014). Various editions of French’s book were cited by other texts in the samples but the 1971 edition was used to represent all subsequent editions.

Much of the literature on methodological pluralism refers to the appeal of positivistic and quantitative approaches to studying human behaviour, and to the limitations that this appeal can mask. Citations are a form of human behaviour, but not necessarily one that is easy to interpret because researchers both publish their own work and cite other people’s work in different ways and for different reasons (Bornmann & Daniel, 2008; Case & Higgins, 2000). Considering the citation map presented here a few specific observations can be made, especially with respect to the need for additional enquiry using other methods (the theme of this article). First, it is difficult to establish a clear basis upon which to define the sampling strategies for the relevant texts (especially for the qualitative texts). Second, all texts and citations are here counted equally, even though some texts are entirely devoted to fixation whilst some only refer to it briefly, and some citations are fairly shallow whilst some are more involved. Third, citation to a text does not mean that the most relevant part of that text is being referred to (for example, French’s book is referred to in some of the experimental texts, but those references are not to the passages that describe fixation).

Fourth, just because one text does not cite another need not indicate that the authors of the later work were not aware of the earlier one. Fifth, the authors of the experimental works might have knowledge of design fixation occurring ‘in the wild’ independently of what is reported in the qualitative literature. In addition to reading the texts and mapping the citations, other methods would be required to more fully understand the interactions between researchers’ knowledge of design behaviour as it occurs in the laboratory and in the wild (e.g. to account for personal communication or personal experience).

## References

- Bastian M., Heymann S., & Jacomy M. (2009). Gephi: an open source software for exploring and manipulating networks. International AAAI Conference on Weblogs and Social Media. San Jose, CA. [<https://gephi.org/> accessed 20/04/2019]
- Bornmann, L., & Daniel, H. D. (2008). What do citation counts measure? A review of studies on citing behavior. *Journal of Documentation*, 64(1), 45–80.
- Boyack, K. W. & Klavans, R. (2010). Co-citation analysis, bibliographic coupling, and direct citation: Which citation approach represents the research front most accurately? *Journal of the American Society for Information Science and Technology*, 61, 2389-2404.
- Crilly, N. (2015). Fixation and creativity in concept development: The attitudes and practices of expert designers. *Design Studies*, 38, 54–91. <https://doi.org/10.1016/j.destud.2015.01.002>
- Crilly, N. (2019). Creativity and fixation in the real world: A literature review of case study research. *Design Studies*. <https://doi.org/10.1016/j.destud.2019.07.002>
- Jacomy, M., Venturini, T., Heymann, S., & Bastian, M. (2014). ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software. *PLOS ONE*, 9(6), e98679. <https://doi.org/10.1371/journal.pone.0098679>
- Sio, U. N., Kotovsky, K., & Cagan, J. (2015). Fixation or inspiration? A meta-analytic review of the role of examples on design processes. *Design Studies*, 39, 70–99. <https://doi.org/10.1016/j.destud.2015.04.004>
- Vasconcelos, L. A., & Crilly, N. (2016). Inspiration and fixation: Questions, methods, findings, and challenges. *Design Studies*, 42, 1–32. <https://doi.org/10.1016/j.destud.2015.11.001>

## Sampling of academic texts

Experimental texts sampled from two reviews ('the sources').

1) Sio, U. N., Kotovsky, K., & Cagan, J. (2015). Fixation or inspiration? A meta-analytic review of the role of examples on design processes. *Design Studies*, 39, 70–99.  
<https://doi.org/10.1016/j.destud.2015.04.004>

From 'supplementary data' (quoted in the order and form listed in the table):

1992 Purcell & Gero  
1993 Purcell, Williams, Gero, & Colbron  
1993 Smith, Ward, & Schumacher  
2002 Dahl & Moreau  
2006 Pettula & Sipilä  
2008 Tseng, Moss, Cagan, & Kotovsky  
2010 Wilson, Rosen, Nelson, & Yen  
2011 Cardoso & Badke-Schaub  
2011 Chan, et al  
2011 Lujun  
2012 Cardoso, Gonçalves, & Badke-Schaub  
2012 Gonçalves, Cardoso, & Badke-Schaub  
2013 Fu & Chan et al.  
2013 Fu & Murphy et al.  
2014 Agogue, et al.  
1991 Jansson & Smith  
2005 Chrysikou & Weisberg  
2009 Hassard, Blandford, & Cox  
2013 Viswanathan & Linsey

2) Vasconcelos, L. A., & Crilly, N. (2016). Inspiration and fixation: Questions, methods, findings, and challenges. *Design Studies*, 42, 1–32.  
<https://doi.org/10.1016/j.destud.2015.11.001>

From 'Table 1' (quoted in the order and form listed in the table):

Cardoso, 2011  
Cheng, 2014  
Chrysikou, 2005  
Dahl, 2002  
Fu, 2013  
Goldschmidt, 2006  
Gonçalves, 2012  
Jansson, 1991  
Liikkanen, 2008  
Linsey, 2010  
Lujun, 2011  
Moreno, 2014  
Nijstad, 2002  
Perttula, 2006a  
Perttula, 2007  
Purcell, 1996  
Sarkar, 2008  
Siangliulue, 2015  
Smith, 1993  
Toh, 2014  
Tseng, 2008  
Viswanathan, 2014  
Yilmaz, 2010  
Youmans, 2011a  
Youmans, 2011b

Collected sample of experimental texts, excluding conference papers:

[Agogu  et al., 2014]  
[Cardoso & Badke-Schaub, 2011]  
[Chan et al., 2011]  
[Cheng et al., 2014]  
[Chrysikou & Weisberg, 2005]  
[Dahl & Moreau, 2002]  
[Fu et al., 2013]  
[Goldschmidt & Smolkov, 2006]  
[Jansson & Smith, 1991]  
[Liikkanen & Perttula, 2008]  
[Linsey et al., 2010]  
[Moreno et al., 2014)]  
[Nijstad et al., 2002]  
[Perttula & Sipil , 2007]  
[Purcell et al., 1993]  
[Purcell & Gero, 1992]  
[Purcell & Gero, 1996]  
[Sarkar & Chakrabarti, 2008]  
[Smith et al., 1993]  
[Toh & Miller, 2014]  
[Tseng et al, 2008]  
[Viswanathan et al, 2014]  
[Wilson et al., 2010]  
[Yilmaz et al., 2010]  
[Youmans 2011a]  
[Youmans 2011b]

In the accompanying data files, square brackets are used to indicate the experimental texts.

Full citations are provided in the sources.

Qualitative texts sampled from two reviews ('the sources').

1) Crilly, N. (2015). Fixation and creativity in concept development: The attitudes and practices of expert designers. *Design Studies*, 38, 54–91.  
<https://doi.org/10.1016/j.destud.2015.01.002>

From Section 1.3 (quoted in the order and form listed in the text):

Darke, 1979

Rowe, 1987

Cross & Cross, 1996 [*sic*: should be Cross & Clayburn Cross, 1996]

Roy, 1993

Candy & Edmonds, 1996

Busby & Lloyd, 1999a

Busby & Lloyd, 1999b

Herring, Chang, Krantzler and Bailey, 2009

Eckert, Stacey, & Earl, 2005

Robertson & Radcliffe, 2006

Robertson & Radcliffe, 2009

2) Crilly, N. (2019). Creativity and fixation in the real world: A literature review of case study research. *Design Studies*. <https://doi.org/10.1016/j.destud.2019.07.002>

All sections (quoted in the order and form listed in the text):

Crilly, 2015 [but omitted from this analysis as it is used as a source]

French, 1971/1998

Barker 1994

Ferguson, 1992.

Roy, 1993

Cross & Clayburn Cross, 1996

Candy and Edmonds, 1996

Cross, 2001

Dogan & Nersessian, 2010

Yilmaz and Seifert's, 2011

The Open University, n.d.

Moulton, 1979

Moulton, 1997

Hickman & Roos, 1982

Landis, 1998

Baylis, 1999

Dyson, 2000

Rothwell & Gardiner, (1985)

Buijs, 1888 [*sic*: should be 1988]

Dasgupta's, 1994

Billington & Billington, 2013

Filho, Tahim, Serafim & Moraes, 2017

Lawson, 1994

Heylighen & Neuckermans, 2002).

Maccoby, 1991

Collected sample of qualitative texts:

{Barker 1994}  
{Billington & Billington, 2013}  
{Buijs, 1988}  
{Baylis, 1999} (no rel citations)  
{Busby & Lloyd, 1999a}  
{Busby & Lloyd, 1999b}  
{Candy & Edmonds, 1996}  
{Cross, 2001}  
{Cross & Clayburn Cross, 1996}  
{Darke, 1979}  
{Dasgupta, 1994}  
{Dogan & Nersessian, 2010}  
{Dyson, 2000}  
{Eckert, Stacey, and Earl, 2005}  
{Ferguson, 1992}  
{Filho, Tahim, Serafim & Moraes, 2017}  
{French, 1971/1998}  
{Herring, Chang, Krantzler and Bailey, 2009}  
{Heylighen & Neuckermans, 2002}  
{Hickman & Roos, 1982}  
{Landis, 1998}  
{Lawson, 1994}  
{Maccoby, 1991}  
{Moulton, 1979}  
{Moulton, 1997}  
{The Open University, n.d.}  
{Robertson & Radcliffe, 2006}  
{Robertson & Radcliffe, 2009}  
{Rothwell & Gardiner, 1985}  
{Rowe, 1987}  
{Roy, 1993}  
{Yilmaz and Seifert, 2011}

In the accompanying data files, curly brackets are used to indicate the qualitative texts.

Full citations are provided in the sources.