Charles Dotter and the Birth of Interventional Radiology: A "Sleeping-Beauty" with a Restless Sleep

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Abstract
Charles Dotter is described as the father of interventional radiology, a medical specialty born at the cross-border of radiology and cardiology. Dotter's landmark paper published in 1964 was poorly cited until 1979 and can be considered from a scientometric point of view as a sleeping beauty. Sleeping-beauties are article that suffer of a delayed recognition. This paper, will explore the bibliometric characteristics of this case study and the accuracy of Van Raan's criteria to define "sleeping beauty" in science will be discussed. "The prince" is identified through citation network analysis, and the sleeping period has been documented as a restless sleep period with science and social controversy that could be documented in publications databases by differentiating bibliographic references. Therefore, a category of "sleeping beauty" –like paper should be introduced. By the end, these observations should open new avenues in identifying "sleeping beauties".

Conference Topic
Citation and co-citation analysis

Introduction

Charles Dotter, father of interventional radiology

Charles Theodore Dotter (1920–1985) was a pioneering US vascular radiologist, credited with developing interventional radiology (IR): he invented the angioplasty and the catheter-delivered stent. On January 16, 1964, he percutaneously dilated a tight, localized stenosis of the superficial femoral artery in an 82-year-old woman with painful leg ischemia and gangrene who refused leg amputation. Percutenous transluminal angioplasty (PTA) was born, and Dotter with his trainee Dr. Melvin P. Judkins, described their technique in a landmark paper published in the medical journal "Circulation" (Dotter, 1964).

Today, Charles Dotter is described as the father of interventional radiology (IR), a sub-specialty of radiology using minimally invasive image-guided procedure to diagnose, as well as to treat diseases in every organ. The Oregon Health Sciences University (OHSU), where he spent his entire medical career, boasts the Dotter Interventional Institute. Furthermore, the Society of Interventional Radiology named a Dr. C.T. Dotter lecture to honor annually extraordinary contributions to the IR field (Rösch, 2003).

However, at first, the relationship between surgeons and radiologists was adversarial because the Dotter technique was a paradigmatic revolution, inviting radiologists to transgress medical specialty boundaries. It can be summed up by Dotter's formula at that time: "The angiographic catheter can be more than a tool for passive means for diagnostic observations; used with imagination, it can become an important surgical instrument". (Payne, 2001).

Therefore, as we found out, Dotter's landmark paper was poorly cited until 1979 and can be considered from a scientometric point of view as a sleeping beauty paper.

Sleeping beauty in scientific literature

In Scientometrics, the phenomenon of delayed recognition has been well described since the pioneering observations of Garfield, and referred to as premature discoveries, resisted discoveries, delayed recognition or sleeping beauties (Burrell, 2005; Braun, 2010). Van Raan (2004) defined "sleeping beauties" as articles that go unnoticed ("sleeps") for a long period of time and then, suddenly, receives a lot of citations by a "prince" (another article). Three variables were defined for such papers: depth of sleep, length of the sleep and awaking intensity. Some publication had heaping before sleeping, and are described as "all-element-sleeping beauties" (Li, 2012).

Objectives

In the present work, we explore the bibliometric characteristics of this case study, question the sleeping-beauty definition, explore the diffusion of Dotter concept during the sleeping period, and document the awaking phase and identify "the prince" through citation network analysis.

Method

A literature search on Dotter C.T. scientific production was conducted both in PubMed and Scopus databases. Citations of Dotter work were extracted from the Web of Science database until 12/31/2013. Then, a descriptive statistics analysis was led on the corpus (219 publications; 7866 citations). Scientific collaborations of C.T. Dotter was explored with Intellixir® to draw co-publications graph. Citations network pattern during time of the landmark paper was drawn using CitNetExplorer software tool (Van Eck, 2014). Complementary queries were run using Dotter or PTA as a keyword in different search fields for different types of documents.

Result

The scientific production of Charles Dotter

Dotter published his first paper in 1948 in a top medical journal, the New England Journal of Medicine (Jan 13; 239(2):51-4). During his 33 years at OHSU, he issued 219 publications; a quarter of his scientific production was disclose in high quality journals, and split between 2 main medical disciplines: radiology and cardiology (Table 1).

Table 1. Journal distribution of C.T. Dotter scientific production.

Source title	*Publications number*	*Impact factor*
Radiology	46	5,561
Am. J. Roentgenol. Radium Ther. Nucl. Med.	27	na
Circulation	19	12,755
New England J Medicine	8	52,589
Am. J. Roetgenol.	6	2,47

Dotter had many relations in the academic community: all along his career he co-published with 140 different authors, mainly with J. Rosch, F. Keller & J. Melvin (340, 215 & 68 co-publications respectively; Fig.1 and Table 2).

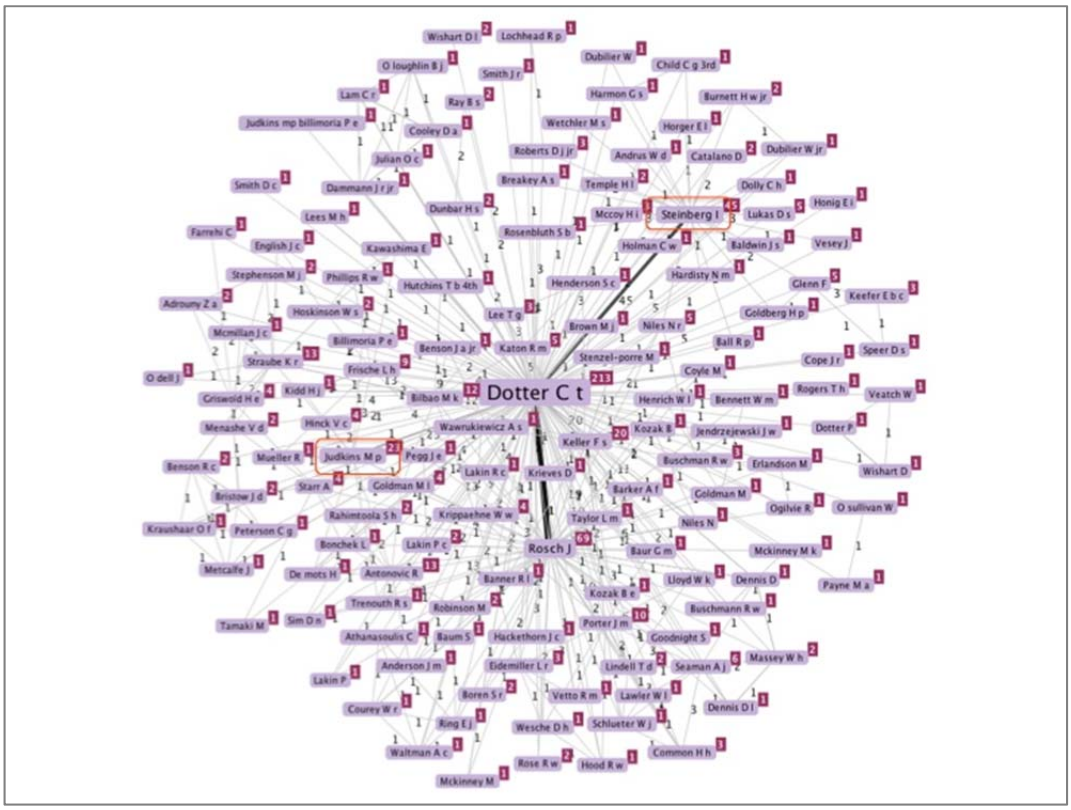

Figure 1. Network of C.T. Dotter co-publications.

Table 2. C.T. Dotter main scientific collaborators.

Author	Lab. / Dpt.	Institution	Publi.
Rösch, Johannes	Center of Cardiac Surgery	Friedrich Alexander University (DE)	340
Keller, Frederick S.	Dotter Interventional Inst.	Orgeon Health & Sciences Medical Center (USA)	215
Steinberg, Israel	Dpt. of Surgery, Medicine & Radiology	New Loma Linda Univ. (USA)	174
Judkins, Melvin P.	Coordinating Center for Collaborative studies in Coronary Artery Surgery	New York Hospital – Cornell Univ. (USA)	68
Bilbao, Marcia K.	Dpt. of Radiology	University of Oregon Mecial School (USA)	22

He published his last paper in 1981, four years before his death. By the end of his career, his scientific work totalized more than 4500 citations and reached 7866 citations at the end of 2013 (Fig. 2).

Dotter successfully diffused his results and obtained recognition from his academic community with an average of 52-251 citations every year.

It is interesting to point out that before his landmark paper was published in 1964, he was already an active researcher with 100 publications, well recognized by his academic community with 1068 citations at that time.

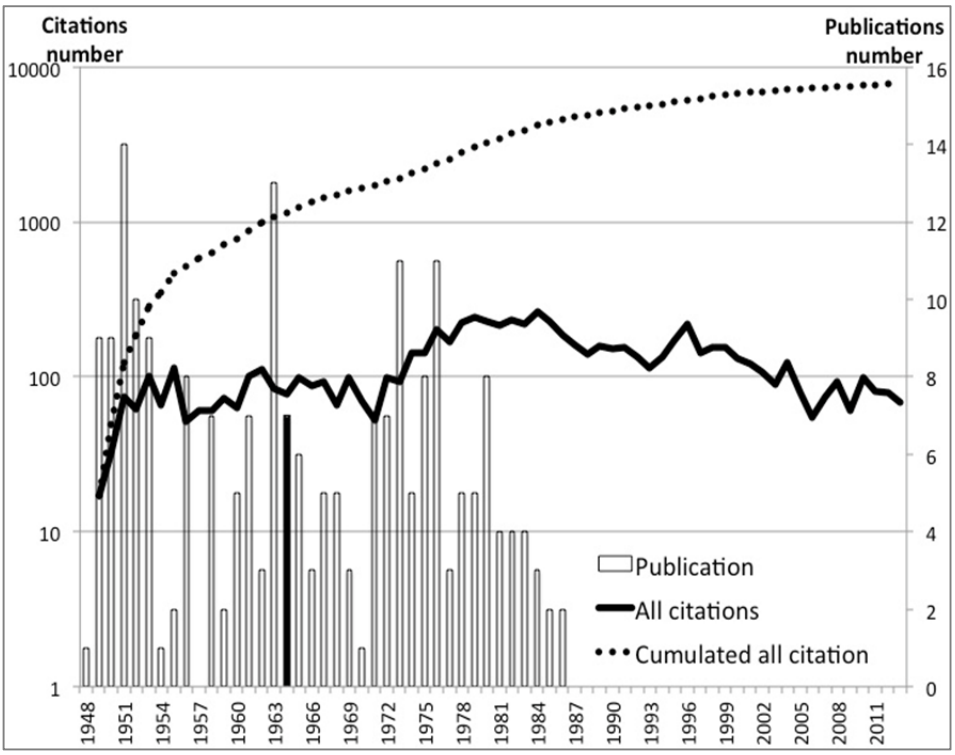

Figure 2. Dotter's publications and citations.

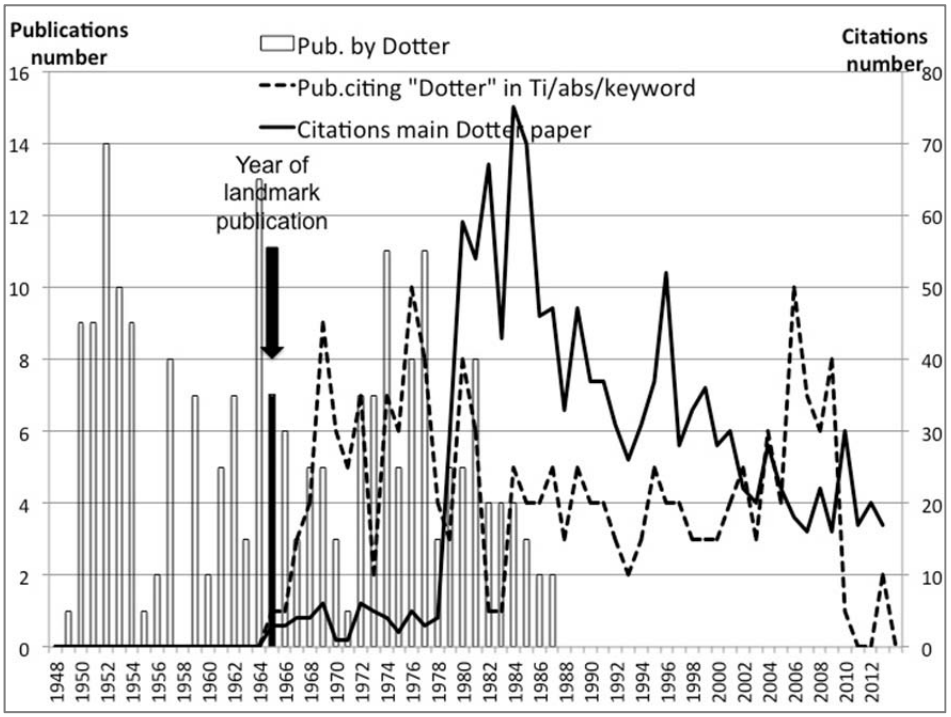

Figure 3. Dotter's main paper citations and Dotter's name apparition in the literature.

Dotter's landmark paper: a sleeping-beauty?

Dotter's landmark paper published in 1964 (Figure 2; black box) was cited with an average of 19.31 citations per year, totalizing 1275 citations today. However, during the first 14 years, his paper was cited only 51 times (Figure 3; full line) before suddenly gaining 29 citations in 1979 and more than 50 citations per year in the latter period.

Therefore, Dotter's main paper has the characteristics of a "sleeping beauty" despite the fact that it does not exactly fit Van Raan's definition (depth of sleep: 3.64 citations/year length of sleep period: 14 years; awake intensity: 52.25 citations/year).

During the delayed recognition period, Dotter was frequently named (n=76) within medical literature (Figure 3: dotted line), as well as his technique, percutaneous transluminal angioplasty (data not show) attesting that the "sleeping period" was traversed by a medical controversy.

The corresponding "Prince" was identified by visualizing the pattern of citations (Fig.4). A German cardiologist, A. Gruntzig, inventor of the coronary balloon angioplasty, was the first to referred to Dotter's previous work. He first did so in a paper published in German in the journal Deutsche Medizinische Wochenschrift in 1974, which had however only very little echo at that time until it was published in English in a well established journal in radiology (American J. of Roentgenology, 132:547-552, April 1979).

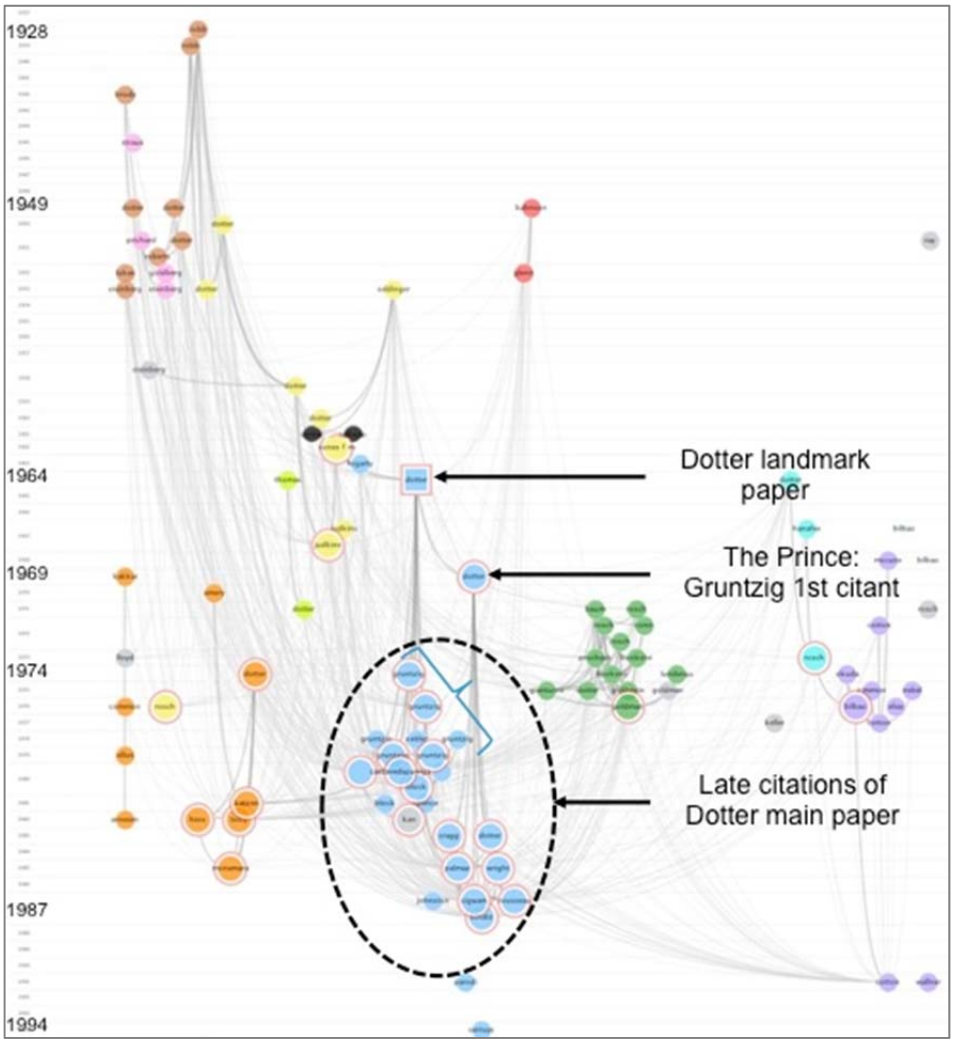

Figure 4. Citation network of CT Dotter paper and its direct and indirect successors.

Later on, Gruntzig's paper, citing Dotter pioneering work, was quickly cited in the medical literature (n=23, year +1) and its peak of citations coincided with the awaking of Dotter landmark paper citations (Figure 5).

Discussions

Dotter landmark paper has the characteristics of a sleeping-beauty but does not fit Van Raan's criteria. Therefore, this case study will discuss the accuracy of Van Raan's criteria to define

"sleeping beauty" in science, and introduce the category of "sleeping beauty" – like as a paper. Beside it is necessary to pinpoint that the sleeping period might indeed be a restless sleep period traversed by scientific controversy that could be traced back in publications databases by differentiating bibliographic references from citations in the text, or by analyzing the nature of the documents, especially article versus editorial, letter or review. These observations should open new avenues in identifying "sleeping beauties" in the literature, and nurture science resistance or controversy study in sociology of science.

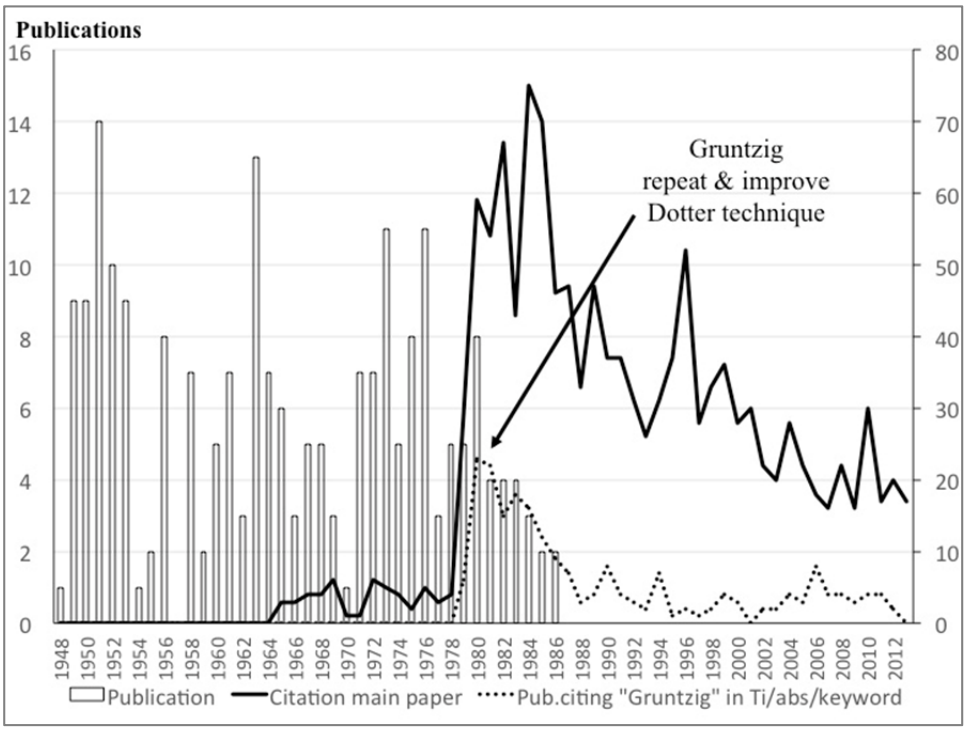

Figure 5. Citations curves of Dotter's paper & Gruntzing refering paper.

Acknowledgments

This work is supported by a grant from the French National Cancer Institute (INCA#6165).

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