Title
Death comes as the end - Effects of cessation of personal influence upon rates of citation of astronomical papers

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An attempt is made to investigate the extent to which direct, personal influence on students, colleagues, and mentors affects the frequency with which a scientist's papers are cited by others working in his field. The method used is an analysis of changes in citation rate between 1965 and 1984 to papers written over their entire careers by an index group of astronomers who died between 1969 and 1982. These citation histories are compared to those of papers written over the same period by a control group of astronomers who were still active at the end of 1984. Only papers written during the lifetimes of the index astronomers are considered.

The data show signs that the death of a scientist is followed by a few-year "sympathy period", during which citation rates rise, and then by a decade or more of gradual forgetfulness, during which citation rates drop off faster than those to papers written during the same period by living astronomers. The amounts of the rise and decline suggest that about 40% of astronomical citations are mediated by personal influence.

1. INTRODUCTION

Most of us believe that the frequency with which a scientific paper is cited depends primarily upon how useful it is to other workers in the field. Most of us also suspect, however (especially when our own papers go uncited), that there are other factors, related to where, when, and by whom the paper is published. One of these factors is direct, personal influence on mentors, colleagues, and students with whom the author communicates. Rao and Vahia [1] have gone so far as to suggest that this personal influence factor may be sufficiently important to account for the rough proportionality that exists between the number of authors of an astronomical paper and the number of times it is cited [2]. Along the same lines, the fact that astronomers typically write their most-cited papers between the ages of 50 and 60 [3] has been attributed by Woltjer [4] to the peaking of personal influence (in the form of directorships, editorships, chairmanships, etc.) during that decade.

The intent here is to probe the effect of personal influence on citation rates. The method is a comparison of the citation histories of papers written by 34 astronomers who died between 1969 and 1982 to the citation histories of papers written by a control group still active in astronomy at the end of 1984. The control individuals were matched as nearly as possible to the index ones in subdiscipline, gender, country of employment, and (most important) year in which career began. This last is important, because average citation rates to astronomical papers peak 5 yr after publication and decline monotonically, and roughly linearly, thereafter, with a half-life near 20 yr [5]. The death dates for the sample were constrained at one end by the appearance of the first cumulative issue of Science Citation Index including astronomical papers (1965—69) and, at the other end, by the time needed for the astronomical community to be aware of the death when writing papers published in 1984.

The usable sample is not very large, leading to a preliminary conclusion that investigations like this require a larger population (or an older one!) than the world's 7000 research astronomers (median age about 40) to achieve great statistical significance.
Nearly 200 members of the International Astronomical Union (whose Bulletin contains a semi-annual necrology) died between 1969 and 1982. Many of them, however, had retired from scientific activities long before; others had devoted most of their later attention to science education, administration, or policy matters, and so had ceased to publish research-oriented papers; and few, though active to the last, had begun their careers so early in the 20th century that no living individual could serve as a suitable control. As a result, the final sample consists of only 34 astronomers who died with their observing boots well polished and who were still being cited with some regularity in 1984. All but two members of the sample appeared as sole or senior of two or more cited papers published less than three years before death (and, in some cases several years after death, owing to the long lead times involved).

For each member of the sample, a control individual was chosen from among the membership of the IAU at the time the index individual died. The control sample is necessary to establish the rate at which citations to papers should drop off with time when the author remains normally influential. Thus first priority was given to matching the year of first published cited paper for index and control astronomers. These agree to within ±1 year in all cases. Next priority went to matching subdisciplines (theory vs. observation; solar, planetary, stellar, and extragalactic studies, etc.). There were 26 good matches, 4 fair ones, and 4 poor. Gender matched in all but one case. Finally, an effort was made to choose control individuals whose careers took place largely in the same place as the sample individuals’ (USSR; UK; continental Europe; USA/Canada; developing countries; early work in Europe followed by migration to USA; etc.). Here there were 22 good matches, 8 fair ones (e.g. US vs. Europe emigrated to US), and 4 poor ones. In only three cases was the match “fair” or “poor” in more than one parameter.

For each index individual, the data consist of the numbers of citations during the periods 1965—1969, 1970—74, 1975—79, and 1984 to papers of which he was sole or senior author, excluding obvious self-citations but including all identifiable variants of the name. There were 23,905 citations, an average of 703 per person (high 5279, low 68) and 43.9 per person per year. This is very close to the 1982 average citation rate of 41.4/yr for randomly-chosen members of the American Astronomical Society [6].

For each control individual, only those citations to papers written before the corresponding sample member ended his active career were counted, for the same periods and again excluding self-citations. There were 31,891 citations, an average of 938 per person (high 2325, low 217) and 58.6 per person per year. This is very close to the 1982 average rate of 54.4/yr for officers of the AAS [6].

It is worth noting that the control astronomers have a 33% higher average citation rate than the sample ones. This is an artifact of how the groups were chosen. The index astronomers automatically identified themselves by dying. But members of the control group had to be conspicuous enough to be readily identifiable in IAU membership lists as working in the same subdiscipline etc. as the corresponding index people. The effects of this difference should be removed by the statistical method described in the next section.

Table I presents only the raw data, which was fairly difficult to extract but fairly easy to analyze. It can be used to check the conclusions that follow or to test other hypotheses.

III. RESULTS AND DISCUSSION

The absolute citation rates range from 1—2 per person per year up to 360 and so are not readily interpretable except as measures of the enormous variability of scientists and science. What we want is a measure of how citation rates for the deceased astronomers have changed in comparison to those for the living ones.
V. Trimble: Death and personal influence on citation rates

Table 1
Numbers of citations 1965–79, 1984 to papers by index (deceased) and control (living) astronomers

<table>
<thead>
<tr>
<th>date of death</th>
<th>index/control astronomers</th>
<th>first/last paper</th>
<th>numbers of citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 1968</td>
<td>Wrubel</td>
<td>1948</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1966</td>
<td>105</td>
</tr>
<tr>
<td>Nov 1969</td>
<td>Deutsch</td>
<td>1945</td>
<td>256</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1971</td>
<td>158</td>
</tr>
<tr>
<td>Feb 1970</td>
<td>Henyey</td>
<td>1937</td>
<td>157</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1972</td>
<td>506</td>
</tr>
<tr>
<td>Jul 1970</td>
<td>Bernas</td>
<td>1953</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1970</td>
<td>217</td>
</tr>
<tr>
<td>Dec 1972</td>
<td>Cameron (R. C.)</td>
<td>1961</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1972</td>
<td>55</td>
</tr>
<tr>
<td>Feb 1973</td>
<td>Bowen</td>
<td>1924</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1973</td>
<td>514</td>
</tr>
<tr>
<td>Dec 1973</td>
<td>Hindmarsh</td>
<td>1954</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1974</td>
<td>176</td>
</tr>
<tr>
<td>Jan 1974</td>
<td>Ferraro</td>
<td>1930</td>
<td>201</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1972</td>
<td>400</td>
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<tr>
<td>Feb 1974</td>
<td>Zwicky</td>
<td>1923</td>
<td>415</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1974</td>
<td>224</td>
</tr>
<tr>
<td>May 1975</td>
<td>Kiepenheuer</td>
<td>1934</td>
<td>120</td>
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<tr>
<td></td>
<td></td>
<td>1975</td>
<td>523</td>
</tr>
<tr>
<td>Sep 1975</td>
<td>Kukarkin</td>
<td>1934</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1976</td>
<td>362</td>
</tr>
<tr>
<td>Nov 1975</td>
<td>Pikelner</td>
<td>1947</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1976</td>
<td>779</td>
</tr>
<tr>
<td>Jan 1976</td>
<td>Minkowski (R.)</td>
<td>1926</td>
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<td></td>
<td></td>
<td>1975</td>
<td>314</td>
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<tr>
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<td>1923</td>
<td>238</td>
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<td></td>
<td></td>
<td>1976</td>
<td>489</td>
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<tr>
<td>Apr 1977</td>
<td>Limber</td>
<td>1953</td>
<td>99</td>
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<tr>
<td></td>
<td></td>
<td>1976</td>
<td>417</td>
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<td>Sep 1977</td>
<td>Huang (S. S.)</td>
<td>1937</td>
<td>157</td>
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<td></td>
<td></td>
<td>1977</td>
<td>953</td>
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<tr>
<td>Nov 1977</td>
<td>Chalonge</td>
<td>1934</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1976</td>
<td>102</td>
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<tr>
<td>Feb 1978</td>
<td>Thackeray</td>
<td>1933</td>
<td>168</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1978</td>
<td>356</td>
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<tr>
<td>Mar 1978</td>
<td>Lallemand</td>
<td>1935</td>
<td>83</td>
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<tr>
<td></td>
<td></td>
<td>1976</td>
<td>176</td>
</tr>
<tr>
<td>Jun 1978</td>
<td>Kaplan (S. A.)</td>
<td>1945</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1979</td>
<td>408</td>
</tr>
<tr>
<td>Apr 1979</td>
<td>McCuskey</td>
<td>1938</td>
<td>64</td>
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<tr>
<td></td>
<td></td>
<td>1976</td>
<td>139</td>
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</table>

The relevant parameter is a double ratio: number of citations in 1984 to papers by deceased astronomer divided by number in last quinquennium he lived through (e.g. 1970–74), divided in turn by the same 1984 to 1970–74 (e.g.) ratio for papers published by the control, living astronomer during the active career of the deceased one. Independent of absolute numbers of citations, this ratio should be unity if death does not affect the influence of one's previous research, greater than unity if there is some sort of sympathy factor, and less than unity if the removal of the effect of personal contact diminishes scientific influence.

Let us call this double ratio \( R \). It ranges from 0.03 to 4.88 with a median value of 0.86 for the 34 astronomers considered. The striking result emerges when we consider \( R \) for astronomers who ceased work in different years. Among the eight who stopped publishing before 1974, \( R \)'s < 1 outnumber \( R \)'s > 1 by 7 to 1. For the group who died between 1974 and 1978, \( R \)'s of less than one again lead by 11 to 4, but among the 11 astronomers who ceased work most recently (1979–82), there are 9 \( R \)'s > 1 and only 2 smaller ones. The medians for the three groups are 0.65, 0.87, and 1.45. One's impression is of a brief outburst of sympathy, followed by gradual forgetting of the deceased's contributions, at least in comparison with those of similar but still active astronomers. A "sympathy period" can also be identified for the first two groups.

<table>
<thead>
<tr>
<th>date of death</th>
<th>index/control astronomer</th>
<th>first/last paper</th>
<th>numbers of citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep 1979</td>
<td>Syrovatskii</td>
<td>1953 111</td>
<td>215 316 43</td>
</tr>
<tr>
<td></td>
<td><em>Ivanov (V. V.)</em></td>
<td>1980 110</td>
<td>248 329 28</td>
</tr>
<tr>
<td>Dec 1979</td>
<td>Payne-Gaposchkin</td>
<td>1925 103</td>
<td>134 205 38</td>
</tr>
<tr>
<td></td>
<td><em>McCrea</em></td>
<td>1977 188</td>
<td>201 274 35</td>
</tr>
<tr>
<td>Mar 1980</td>
<td>Myerscough</td>
<td>1962 27</td>
<td>23 17 1</td>
</tr>
<tr>
<td></td>
<td><em>Jordan (C.)</em></td>
<td>1972 62</td>
<td>278 402 46</td>
</tr>
<tr>
<td>Apr 1980</td>
<td>Bullard</td>
<td>1930 367</td>
<td>641 528 75</td>
</tr>
<tr>
<td></td>
<td><em>Cowling</em></td>
<td>1978 417</td>
<td>297 270 42</td>
</tr>
<tr>
<td>Apr 1980</td>
<td>Johnson (H. L.)</td>
<td>1947 1422</td>
<td>1777 1794 286</td>
</tr>
<tr>
<td></td>
<td><em>Code</em></td>
<td>1980 125</td>
<td>271 406 51</td>
</tr>
<tr>
<td>Dec 1980</td>
<td>Wyatt</td>
<td>1950 30</td>
<td>23 41 10</td>
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<td><em>McNamara</em></td>
<td>1977 121</td>
<td>97 100 5</td>
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<tr>
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<td><em>Anders</em></td>
<td>1978 467</td>
<td>544 804 51</td>
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<tr>
<td>May 1981</td>
<td>Tinsley</td>
<td>1967 11</td>
<td>86 464 69</td>
</tr>
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<td></td>
<td><em>Trimble</em></td>
<td>1981 28</td>
<td>187 311 66</td>
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<tr>
<td>Oct 1981</td>
<td>Serkowski</td>
<td>1956 99</td>
<td>235 382 48</td>
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<td></td>
<td><em>Low</em></td>
<td>1980 343</td>
<td>571 337 29</td>
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<tr>
<td>Dec 1981</td>
<td>Whelan</td>
<td>1970 0</td>
<td>31 89 20</td>
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<tr>
<td></td>
<td><em>Pringle</em></td>
<td>1979 0</td>
<td>119 449 37</td>
</tr>
<tr>
<td>Feb 1982</td>
<td>Neyman (J.)</td>
<td>1923 374</td>
<td>331 471 56</td>
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<tr>
<td></td>
<td><em>Opik</em></td>
<td>1980 461</td>
<td>503 382 38</td>
</tr>
<tr>
<td>Aug 1982</td>
<td>Bappu</td>
<td>1951 30</td>
<td>48 38 18</td>
</tr>
<tr>
<td></td>
<td><em>Blanco (V. M.)</em></td>
<td>1981 121</td>
<td>236 363 56</td>
</tr>
<tr>
<td>Nov 1982</td>
<td>Linfoot</td>
<td>1943 141</td>
<td>100 104 25</td>
</tr>
<tr>
<td></td>
<td><em>Gascoigne</em></td>
<td>1972 116</td>
<td>133 126 17</td>
</tr>
</tbody>
</table>

*) Since deceased.
who died between 1969 and 1978. An analysis like the present one carried out in the quinquennia immediately following their deaths would have found $R$'s greater than unity leading by 5 to 3 in the first group and 9 to 6 in the second.

A number of colleagues with whom these results have been discussed have claimed that they are exactly what one expects in the wake of death — a brief period of memory and sympathy, followed by gradual forgetfulness. They are probably right, and perhaps the main lesson is that there is a lot of human nature in all of us.

The amounts by which the median $R$'s for the various groups deviate from 1.0 suggest that about 40% of astronomical citations may be mediated by some degree of personal influence. Rao and Vahia [1] reach a rather similar conclusion, using a very different data base and method.

I am indebted to Prof. L. Woltjer for suggesting the hypothesis that originally motivated this investigation and to the editors of Czech. J. Phys. for the opportunity to test it.

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References