

**CORRESPONDENCE OF HUYGENS
CONCERNING
THE BILLS OF MORTALITY OF JOHN GRAUNT**

EXTRACTED FROM VOLUME V
OF THE
OEUVRES COMPLÈTES
OF
CHRISTIAAN HUYGENS

From No. 997
R. Moray to Christiaan Huygens
16 March 1662

this 6 March

...I have three of them to send to you, of which two will depart with the first convenience, the other soon afterwards. One of the two is the response¹ that Mr. Wallis made to Hobbes which will make you laugh much if I am not mistaken, although he prods Mr. Hobbes in a very moving way. The other is a very lovely compilation of observations² on The Weekly Bills of Mortality, which has given desire to our mind to think of some things which will be very useful, from which I will predict to you when they will be dead. The third is the response that Mr. Boyle makes to Mr. Hobbes, which will give you perhaps as much satisfaction as the others. . . .

From No. 1013
R. Moray to Christiaan Huygens
16 May 1662
Chr. Huygens responds in No. 1022

At Whitehall this 6 May 1662

...It is true that I await from you some word of reflection on those Observations of Mr. Graunt.³ I believe that you will not be at all dissatisfied with it. If people took account, in all the cities of the Europe, of the illnesses of which one dies, with the other things which

Date: February 8, 2009.

Translated by Richard J. Pulskamp, Department of Mathematics and Computer Science, Xavier University, Cincinnati, OH. Prepared on February 8, 2009.

¹Hobbius Heauton-Timorumenos. Or a Consideration of Mr. Hobbes his Dialogues. In an Epistolary Discourse, addressed to the Honorable Robert Boyle, Esq; By John Wallis. D.D. Professor of Geometry in Oxford. Oxford, Printed by A. H. L. Lichfield, for Samuel Thomson, at the Bishops-head in S. Pauls Church-yard. London 1662 in-8°.

²This work was published in January 1662.

³John Graunt was born 24 April 1620 in London, where he died 18 April 1674. He was a mercenary soldier and became a member of the Common Council and major of the London militia. Raised under Puritanism, he declared himself Socinian and became finally Catholic. In 1662 he would be elected to the Royal Society, under the express desire of the King. His book cited in Letter No. 997 is the first work on statistical mortality published in Europe.

are themselves observed in the Weekly Bills of Mortality, which are made for several years, in London, and which there he himself adds some other remarks that one would endeavor to notice now (of which you will know the particularity in some time) it would make a thing of great usefulness in several considerations. Let me know, if one makes such observations of the number of deaths &c. in your cities of Holland or not....

From No. 1022
 Christiaan Huygens to R. Moray
 9 June 1662

This is a response to Nos. 997 and 1013. R. Moray responds in No. 1034.

At The Hague this 9 June 1662.

...The discourse of Graunt is very worthy of consideration and pleases me greatly, he argues well and cleanly and I admire how he is prudent in drawing all those consequences out of those simple observations, which don't seem to have served for anything until him. In this country now people do not do it at all, although it would be wished that one had this curiosity and the thing is easy enough, principally in the city of Amsterdam, which is entirely divided into quarters, and in each there are some prefects who know the number of the persons and all that which happens there....

From No. 1755
 Lodewijk Huygens to Christiaan Huygens
 22 August 1669

...With regard to age, I have made a Table these days past of the time that there remains to live, for some persons of all sorts of ages. This is a consequence which I have drawn from this table of the English book Of the Bills of Mortality,⁴ which I send you now a copy,⁵ so that you would take the difficulty of making a few of the same calculations, and that we could see how our calculations will agree. I acknowledge that I had enough difficulty to come to completion, but to you it won't be the same with it, and the consequences which result from it are very pleasing and the same can be useful for the compositions of the life pensions. The question is until which age should a child naturally live as soon as he is conceived. Then a child of 6 years, then one of 16 years, of 26, etc. If you find with it some difficulty or too much inconvenience, I myself offer to make you part of my method, which is certain, by the first opportunity.

Farewell.

According to my calculation you will live until about the age 56 years and half. And I until 55.

From No. 1756
 Christiaan Huygens to Lodewijk Huygens
 28 August 1669
This is a response to No. 1755.

At Paris this 28 August 1669.

...This is a good feat by you, to have done with so little the calculation of the ages, of which you say to have come to completion. But to conclude that this calculation is exact

⁴See the note to Letter No. 997.

⁵See the piece No. 1772.

it would be necessary to have a table which indicates from year to year how many die of the 100 persons that one supposes, and it is necessary that you have supplied it by some means as I know for this, or otherwise you don't know how to determine accurately, how long might live a person of 6, 16 or 26 years &c. and again even less to some mean age between those years, as you have undertaken of you and of me. I believe therefore that you determined some of them only approximately.

That which I then conclude for certain by the data of the table is that he who would wager that a newborn child (or conceived as you say, but it seems me that the Englishman didn't speak of some conceived for how can one have record of it) will live to 16 years, would take the bad share and would wager 4 against 3. Likewise, who would wager that a person 16 years will live until 36, he bets likewise 4 against 3.

I have desire to supply the table as I said and resolve the problems that one could suggest in this matter that is rather subtle. Your method isn't known to be the same as mine, and I will be very pleased to see it. Farewell.

From No. 1771
Lodewijk Huygens to Christiaan Huygens
30 October 1669

This is a response to No. 1756. Chr. Huygens responds in Nos. 1775 and 1776.

At The Hague 30 October 1669

... I confess that my calculation of the ages is not completely correct but there is so little to say that this is not at all significant, and much less so as the English table, on which we base ourselves, is not to this last exactness moreover, but as says that author,⁶ "those numbers are practically near enough to the truth, for men do not die in exact proportions nor in fractions." Here is therefore the method of which I have served myself. I count firstly the years that all these 100 persons jointly must have lived, which are in all 1822 years, this that you will see proven in the page which follows.

The 36 persons who die before 6 years lived on both sides of 3 years, which makes	108 ans.
The 24 who die between 6 and 16 lived on both sides of 11 years, which makes... .264.	
The 15. who die between 16. and 26. lived 21. years, which makes.....315.	
the 9. between 26. and 36. lived 31. years, which makes 279.	
the 6 between 36. and 46. lived 41. years, which makes 246.	
the 4. between 46. and 56. lived 51. years, which makes 204.	
the 3. between 56. and 66. lived 61. years, which makes 183.	
the 2. between 66. and 76. lived 71. years, which makes 142.	
And the one who dies between 76. and 86. lived 81 years.....81.	
	sum 1822 years

These 1822 years you divide equally among 100 persons. There comes to each 18 years and about 2 months, which is the age of every created or conceived person, on both sides. For note in passing that it is of the conceived persons that the Englishman speaks, and he can well keep record of it as well as of those who were born, because the miscarriages also enter into his observations.

Now in order to come to our sum and specify how much there remains of lifetime to every person of such or such an age, here is how I do.

⁶John Graunt.

I take off firstly the 108 years (which is the age of the 36 children who die before the age of 6) from this total number of 1822 years; remainder 1714 years, which must be divided among the 64 persons who remain, this which makes for each, that is to say for every child of 6 years, 26 years and about 10 months so that there remains to them yet to live from the aforesaid age of 6 years, 20 years and 10 months.

Next take off of this 1714 years, the age of the 24. persons who die between 6. and 16. (which is 264 years) there will remain 1450. Which must be divided among the 40. persons who remain, this which makes for each of them, that is to say, for every person

		years	months
of 16. years	36. years and 3. months, so that there remains of life	20.	3.
For those of 26.	there will come 45. years 4. months, or for the rest	19.	4.
For those of 36.	53. years 6. months; for the rest	17.	6.
For those of 46.	61. years. For the rest	15.	–
For those of 56.	67. years and 6 months. For the rest	12.	8.
For those of 66.	74 years 4. months. For the rest	8.	4.
For those of 76.	81. years. For the rest	5.	0.
For those of 86.	Nothing	0.	

When I want to determine the age of one person who is between 36 and 46 for example, like you and I, I adjust their future years in proportion to those which they exceeded more or less the aforesaid number of 36 and also the remainder.

Next from that which is above I don't understand the reason of your count of 4 against 3. For in my opinion the share is about equal when one wagers that a person of 6 or one of 16 will live about 20 more years. I await therefore your reasons as I have sent to you mine....

No. 1772
Lodewijk Huygens to Christiaan Huygens
Appendix to No. 1771
1669

Copy of the English table.

Of 100, there dies within the first six years	36.
The next 10. years or decade	24.
The second decade	15.
The third decade	9.
The fourth	6.
The next	4.
The next	3.
The next	2.
The next	1.
From whence it follows, that of the said 100. conceived there remains alive	
At 6. years end	64.
At 16. years end	40.
At 26.	25.
At 36.	16.
At 46.	10.

At 56	6.
At 66	3.
At 76.	1.
At 80.	0.

From No. 1775
 Christiaan Huygens to Lodewijk Huygens
 14 November 1669
This letter is a response to No. 1771.

At Paris this 14 November 1669

. . . I will think of it more at leisure, and I find your method very lovely, provided that it is really true.

No. 1776
 Christiaan Huygens to Lodewijk Huygens
 21 November 1669
This is a response to No. 1771.

At Paris this 21 November 1669.

I have just investigated your calculation of the ages, and redoing mine that I had lost.⁷ I would wish that yours were correct, since it would give us a little more lifetime, but it serves nothing to flatter us; "Seit nos Proserpina canos,"⁸ and she doesn't stop to count what we are allotted. You conclude near enough to the truth, that the 100 persons have altogether 1822 years of life, but it doesn't follow that the 18 years and 2 months, which comes by dividing that number by 100, would be the age of each created or conceived person, as also you hold for certain. Take, for example, that men are again weaker in their childhood than otherwise, and that of 100 there die ordinarily 90 of them in the first 6 years, but that those also who surpass this age are some Nestors, and Methuselahs, and that they live ordinarily as long as 152 years and 2 months. You will have for the 100, the same number of 1822 years, and however he who would wager, that a conceived child would survive in life then to the age of 6 years alone, would have a great disadvantage, since of 10 there is only one who survives to it.

Here again is another instance. Take that out of 100 conceived children (in the ordinary assumption) I wager for each of them that he will attain the age of 16 years. It is certain that since of 100 there remains of them ordinarily only 40 of 16 years, that I would have the disadvantage and that I must have pledged only 40 against 60, or 2 against 3, in order to make the parts equal.

And hence you see that the 18 years 2 months is not at all the age of each one who is conceived, and I find it only about 11 years.

He who would wager that a child of 6 years will live until 26 could bet 25 against 39, since of 64 children of 6 years, there are 25 of them who will survive to the age of 26 years, against 39 who will die before.

And who would wager that a boy of 16 years will live until the age of 36, could bet 16 against 24 or 2 against 3. Altogether it is a little more advantageous for one of 16 years than for one of 6 of living 20 years more.

⁷See the piece No. 1777.

⁸See Martial's Epigrams III, 43, verse 3 where he says: *scit te Proserpina canum.*

This calculation as you see is very certain and very easy, but you will ask how I am able to determine like you, how much life there remains reasonably to one person of a proposed age. In order to make this I have supplied the small English table, without however inconvenience to me of any calculation, but tracing on it a curved line, on which with the compass I measure the lifetime of the one who one wants, and I see for example that at your age of 38 years, you can still make state of 19 years and 4 month approximately. But if you amuse yourself in challenging often some people to battle you, it is necessary again to reconsider some things. I will send you the line of lifetime another time with the rules therein of it and likewise a table of the lifetimes at each age from year to year, which will cost me scarcely....

No. 1777
 Christiaan Huygens
 Appendix I to No. 1776
 21 November 1669⁹

In examining the calculations of my brother Lodewijk.

21 November 1669

On the observations made in London with great exactitude.

Of 100 persons conceived there die of them	<table border="0"> <tr><td>36</td><td>at the end of 6 years</td></tr> <tr><td>24</td><td>between 6 and 16 years</td></tr> <tr><td>15</td><td>between 16 and 26.</td></tr> <tr><td>9</td><td>between 26 and 36.</td></tr> <tr><td>6</td><td>between 36 and 46.</td></tr> <tr><td>4</td><td>between 46 and 56.</td></tr> <tr><td>3</td><td>between 56 and 66.</td></tr> <tr><td>2</td><td>between 66 and 76.</td></tr> <tr><td>1</td><td>between 76 and 86.</td></tr> </table>	36	at the end of 6 years	24	between 6 and 16 years	15	between 16 and 26.	9	between 26 and 36.	6	between 36 and 46.	4	between 46 and 56.	3	between 56 and 66.	2	between 66 and 76.	1	between 76 and 86.
36	at the end of 6 years																		
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6	between 36 and 46.																		
4	between 46 and 56.																		
3	between 56 and 66.																		
2	between 66 and 76.																		
1	between 76 and 86.																		
therefore of 100 persons those who attain the age of	<table border="0"> <tr><td>6</td><td>years are 64</td></tr> <tr><td>16</td><td>years — 40</td></tr> <tr><td>26</td><td>years — 25</td></tr> <tr><td>36</td><td>years — 16</td></tr> <tr><td>46</td><td>years — 10</td></tr> <tr><td>56</td><td>years — 6</td></tr> <tr><td>66</td><td>years — 3</td></tr> <tr><td>76</td><td>years — 1</td></tr> <tr><td>86</td><td>years — 0</td></tr> </table>	6	years are 64	16	years — 40	26	years — 25	36	years — 16	46	years — 10	56	years — 6	66	years — 3	76	years — 1	86	years — 0
6	years are 64																		
16	years — 40																		
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36	years — 16																		
46	years — 10																		
56	years — 6																		
66	years — 3																		
76	years — 1																		
86	years — 0																		

who would wager therefore that an infant conceived would live until 6 years could bet 64 against 36, or 16 against 9.

and who would wager that an infant conceived will live until 16 years is able to bet only 40 against 60, or 2 against 3, since of 100 there will be only 40 of them who survive until the age of 16 years.

But who would wager that a child of 6 years will live until 16 is able to bet 40 against 24 or 5 against 3, since of 64 persons of 6 years there are 40 of them who survive until 16 and 24 die before.

⁹These pieces No. 1777 and 1778, which evidently are those of which Chr. Huygens speaks in Letter No. 1776, are found in his *Adversaria*.

Similarly who would wager that a lad of 16 years will live until 26 is able to also bet 5 against 3, since of 40 persons of 16 years there are 25 who survive until 26 years, and 15 who die before.

Who would wager that a child of 6 years will live until his 26 year is able to bet 25 against 39, since of 64 children of 6 years there are only 25 who will survive to the age of 26 years and the other 39 die before.

Similarly on one of 16 years who would wager that he will live until his 36th, is able to bet 16 against 24 or 2 against 3, so that it is a little more favorable for one of 16 years than for one of 6 to live another 20 years.

$$\text{multiply } \left\{ \begin{array}{l} 36 \text{ by } 3 \\ 24 \text{ by } 11 \\ 15 \text{ by } 21 \\ 9 \text{ by } 31 \\ 6 \text{ by } 41 \\ 4 \text{ by } 51 \\ 3 \text{ by } 61 \\ 2 \text{ by } 71 \\ 1 \text{ by } 81 \end{array} \right\} \text{ makes } \left\{ \begin{array}{r} 108 \\ 264 \\ 315 \\ 279 \\ 246 \\ 204 \\ 183 \\ 142 \\ \underline{81} \\ 1822 \end{array} \right\}$$

of one hundred infants conceived there die 36 of them before the age of 6 years, of whom, one is able to say having survived, on both sides, 3 years.

of the 64 remaining of 6 years there die of them 24 before the age of 16 years, of whom they survive on both sides, 11 years.

And also of the rest as I have in this table.

1822	by	100
<u>108</u>		
1714	by	64
<u>264</u>		
1450	by	40
<u>315</u>		
1135	by	25
<u>279</u>		
856	by	16
<u>246</u>		
610	by	10
<u>204</u>		
406	by	6
<u>183</u>		
223	by	3
<u>142</u>		
81	by	1

Therefore an infant conceived has 36 chances to live 3 years
 and 24 chances to live 11 years
 and 15 chances to live 21 years
 etc.

Therefore by my rule of the games of chance it is necessary to multiply each number of chances by the years which they give, and to divide the sum of the products, which is here

1822, by the sum of all the chances which are here 100. And the quotient, which is here 18 years and about $2\frac{1}{2}$ months, will be that which is worth the chance of an infant conceived.

The method of my brother Lodewijk reverts to the same thing, although he may have arrived to it by another route.

But although the expected value of an infant conceived is worth these 18 years and $2\frac{1}{2}$ months, this is not in saying that it is apparent that he will live so long, for it is much more apparent that he will die before this term. So that if one wished to wager that he will survive, the share would be disadvantageous. For one is able only to wager with equal advantage that he will survive until about 11 years. Therefore it is mistaken also to say that when one wagers, that a child of 6 years or of 16 years will live another 20 years, the share is equal. For one is able to bet only 25 against 39 on the one of 6 years, and 2 against 3 on the one of 16. Although the expected value of the one and the other is 20 years, that is to say, that they would be mistaken in accepting less than 20 years guaranteed. His calculation is good for the pension.

In order to know in what time 40 persons of 46 years there die 2 of them. It is 1 year 3 months.

Of 10 there die 4 between 46 and 56.

Therefore of 40 there die 16 between 46 and 56 that is to say in 10 years

deaths	in	years	deaths
16	—	10	2 1 year 3 months ¹⁰

A man of 56 years marries a woman of 16 years, how long are they able to make a state of life together without one or the other dying. Or else if one had promised to me 100 francs at the end of each year they will live together, for how much would it be exactly that one bought back this obligation. Likewise in how many years must the two die.

In how many years will 40 men die of 46 years each?

In how many years will die 2 persons of 16 years each? Answer in 29 years $2\frac{2}{3}$ months.

	Age where they survive
an infant conceived has life remaining of 18,22 or 18 years $2\frac{2}{3}$ months nearly	18,22
one of 6 years has life remaining of 20,81 or 20 years 10 months	26,81 ¹¹
one of 16 years has life remaining of 20,25 or 20 years 3 months	36,25
one of 26 years has life remaining of 19,40 or 19 years 5 months	45,40
one of 36 years has life remaining of 17,50 or 17 years 6 months	53,50
one of 46 years has life remaining of 15,00 or 15 years	61,00
one of 56 years has life remaining of 11,67 or 11 years 8 months	67,67
one of 66 years has life remaining of 8,33 or 8 years, 4 months	74,33
one of 76 years has life remaining of 5,00 or 5 years 0 months	81,
one of 86 years has life remaining of 0,00 or 0 year 0 month	86,

In order to know how long will live the latter of 2 persons of 16 years, it is necessary to imagine that each of them draw a ballot out of 40 (complete) of which there are

15	which give	5 years
9	which give	15 years
6	which give	25 years
4	which give	35 years
3	which give	45 years
2	which give	55 years
1	which gives	65 years

And that they will draw 2 ballots the one who has the greatest years for lifetime of the last.

Suppose that one draws first his ballot, and it is certain that he has 15 chances in order to have one of them that give 5 more years of life. And 9 chances in order to have one of them of 15 years of life, &c. Now if he draws one of 5 years of life, it is necessary after this that the other person draw also his ballot. And all that which falls due him to the lesser of 5 years, renders no harm, since the first has drawn a ballot of 5 years, so that all that which is able to fall due to the second less than 5 years, is worth as much as 5 years. But this second has 15 chances of which $7\frac{1}{2}$ are for life less than 5 years, and $7\frac{1}{2}$ for life 6 or 7 or 8 or 9 or 10 years, which is worth as much as $7\frac{1}{2}$ for life 8 years.

And again 25 chances which is worth a man of 16, $20,40^{12}$ years (for these must be taken as this since not one of these 25 chances gives less than 5 years). Therefore the first in drawing his ballot has 15 chances in order to have —

- $7\frac{1}{2}$ chances to 5 years
- $7\frac{1}{2}$ chances to 8 years
- 25 chances to 29,40 years.

This first in drawing has also 9 chances in order to take a ballot of 15 years, and in taking one of these, all that which is able to fall to the other of less than 15 years is worth as much as 15 years. But this second has 15 chances which give less than 15 years, which are therefore as much as 15 chances to 15 years. And he has 9 of which $4\frac{1}{2}$ are to the less of 15 years which are therefore as much as 15 years, and the other $4\frac{1}{2}$ for 16, 17, 18, 19 or 20 years which are worth as much as $4\frac{1}{2}$ for 18 years. And again 16 chances to live $37\frac{1}{2}$ years.

15 —	$7\frac{1}{2}$ — 5	20, 3
	$7\frac{1}{2}$ — 8	
25 —	29, 40	24, 3
9 —	$19\frac{1}{2}$ — 15	
	$4\frac{1}{2}$ — 18	30, 2
	16 — $37\frac{1}{2}$	
6 —	27 — 25	37, 6
	3 — 28	
	10 — 45	46, 1
4 —	32 — 35	
	2 — 38	55, 3
	6 — 51, 67	
3 —	$35\frac{1}{2}$ — 45	65, 0
	$\frac{1}{2}$ — 48	
	3 — 58, 33	65, 0
2 —	38 — 55	
	1 — 58	65, 0
	1 — 65	
1 —	39 — 65	65, 0
	1 — $66\frac{1}{2}$	

Therefore the first in drawing has also $19\frac{1}{2}$ chances to 15 years
 $4\frac{1}{2}$ chances to 18 years
16 chances to $37\frac{1}{2}$ years.

And thus always as here in the margin.

The first of them draws

¹²This is an error. It should read 29,40.

15	chances to 20,3	304,5
9	chances to 24,3	218,7
6	chances to 30,2	181,2
4	chances to 37,6	150,4
3	chances to 46,1	138,3
2	chances to 55,3	110,6
1	chance to 65,0	65,0
		1168,7

29,22¹³ years that he will live the last of 2 persons of 16 years each. That is to say that one of 2 survives to the age of 45 years and $2\frac{2}{3}$ months.

In order to know in how much time will die one of 2 persons each of 16 years, it is necessary a second time to imagine that one after the other draws a ballot from 40 (total) of which there are of them 15 which give 5 years

9 which give 15 years &c.

the same as in the preceding question, but which here it is necessary to take the years of the lesser ballot.

The first in drawing his ballot has 15 chances in order to live 5 years: 9 chances in order to live 15 years &c. And if he takes one of the 15 ballots of 5 years; the other in drawing from them next some ballot which he draws, he is able to use nothing past 5 years, since of 2 ballots, one stops at the lesser. But on the contrary he is able again to diminish by something; because it is necessary to consider in his regard the 15 ballots of 5 years, as he had $7\frac{1}{2}$ of to the lesser of 5, which would be worth only 5 however, and $7\frac{1}{2}$ of 5 or 4, or 3 or 2 or 1 years. Now this second beyond these 15 ballots or chances he has yet 25 which he is able to value only as 5 years. Therefore the first drawing of them has 15 chances in order to have $7\frac{1}{2}$ chances to 3 years
and $32\frac{1}{2}$ chances to 5 years.

The first has also in drawing 9 chances in order to have a ballot of 15 years. And suppose he draws one of them, the other in drawing next is able to draw nothing which serves to pass these 15 years. But he is able to diminish, firstly if he draws one of the 15 of 5 years or one of the $4\frac{1}{2}$ which exist below 15 worth as much as 13 years; the other $4\frac{1}{2}$ being worth therefore 15 alone although they are above. Now this second beyond these 15 and 9 that is to say 24 chances there are yet 16 which are able to be worth also only 15. Therefore the first in drawing had also 9 chances in order to have 15 chances to 5.

$4\frac{1}{2}$ chances to 13.
 $20\frac{1}{2}$ chances to 15.¹⁴

a) They relate to conception because of the ballots the miscarriages are also marked.
[Chr. Huygens].

¹³Amount, found by dividing the preceding sum by 40, the total number of chances.

No. 1778
 Christiaan Huygens
 Appendix II to No. 1776.
 [21 November 1669]

On the straight line below¹⁵ are marked the ages of persons and at the 6 there is a perpendicular of 64 parts since of 100 persons according to the English table there remain 64 at the age of 6 years. On the 16 there is a perpendicular of 40 parts since to the age of 16 years there remain 40 persons of the 100 who were conceived, and also of the remainder. And through all the points or extremes of these perpendiculars I have drawn the curved line 64, 40, 25 &c. If I wish to know now how many there remain of the persons after 20 years of 100 persons conceived, I draw on the line below the age of 20 years at point A from which I erect a perpendicular which joins the curve at B, I say that AB, which taken on the scale below makes nearly 33 parts, is the number of persons who of the 100 conceived attain the age of 20 years. But if I wish to know of them next how long a person of 20 years remains reasonably to live for example, I take the half of BA and fit in DC between the curve and the straight line so that it will make a perpendicular to the latter. And I have AC for the years which remain to life to the said person, which is near to 16 years, as it appears by the divisions of which each is a year. The reason is, that the perpendicular DC being the half of BA which marks the number of men who remain of the 100, 20 years after conception, known to be 33, this DC falling on 36 of the straight line will mark what remains of the half of 33, that is to say, $16\frac{1}{2}$ men after the 36 year. Thus since of 33 persons of 20 years the half die ordinarily in approximately 16 years, one is able to wager with equal advantage that one person of 20 years will live yet 16 years, one will find similarly that the life of an infant conceived must be assessed to 11 years instead of as my brother¹⁶ would contend 18 and 2 months.

No. 1781
 Christiaan Huygens to [Lodewijk Huygens]
 28 November 1669

To Paris this 28 November 1669.

The calculation that I have sent¹⁷ you will have inconvenienced you without doubt, to which having wondered since, and also to you¹⁸, I find that we have both reason in taking the choice in a different sense. You give to an infant conceived 18 years, and $2\frac{1}{2}$ months of life, and it is true that his expectation is valued as much as that. However it is not apparent that he will live so long, for it is much more apparent that he will die before this term. So that if one would wish to wager that he survives, the part would be disadvantageous, for one is able only to wager with equal advantage that he will live until approximately 11 years, as I find it by my method. Similarly the expectation of a child of 6 years or a boy of 16 is worth 20 years as you say, but you could not conclude from it that in wagering that he would live yet 20 years, the share would be equal. Because for this, one must wager only 25 against 30 on those of 6 years, and 2 against 3 on those of 16 years. Or otherwise on one of 16 years one is able to wager 1 against 1 that he will live yet 15 years.

There are therefore two different choices for the expectation or the value of the future age of a person, and the age to which there is equal likelihood that he will survive or not survive. The first is in order to set the life pension, and the other for wagers. I will see if you

¹⁵See the figure.

¹⁶Lodewijk Huygens.

¹⁷Consult Letter No. 1776.

¹⁸Consult Letter No. 1771.

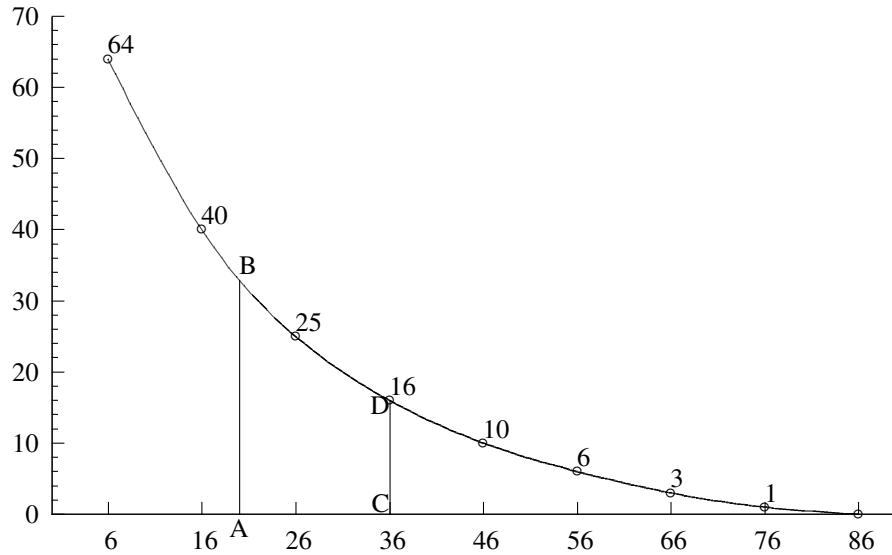


FIGURE 1. No. 1778

have made the same distinction. Nevertheless your method is quite good and subtly found. It reverts correctly to the same thing that I find according to my rules of chance printed in the *Exercitationes Mathematicae* of Schooten,¹⁹ in saying that an infant conceived for example has 36 chances for 3 years life, 24 chances for 11 years &c. For it is necessary by the rule, to multiply each number of chances by that which they give, and to divide the sum of the products by the sum of the total chances in order to have the value.

For your captains²⁰ you are to use the English table as I believe. In saying if of 10 persons there die 4 between 46 and 56 years, therefore of 40 there will die 16 between the ages of 46 and 56 years, that is, in 10 years time. And if 16 die in 10 years, therefore 2 die in 1 year 3 months, by the rule of three. However for this calculation there would die 2 of 40 of them in 15 months in supposing them 46 years each,²¹ and not 50. And similarly it would not be necessary again completely the 15 months since he dies not equally during the 10 years, but more in the first years by reason that the number of persons is greater than after as death has taken away some of them.

Here is a nice enough question which seems to me much more difficult than that of the Captains, and that I have not yet calculated, but I see the means to make it. Two persons of 16 years each, how long can they hope to live together without one or the other dying? Likewise in what time will they both die? These are indeed 2 different questions, and where there is thought to each.²²

The ages of 2 persons are put different as one of 16 and the other of 56, this would bring yet some change but there would not be great difficulty after one would have found the

¹⁹This refers to the work *De ratiociniis in ludo aleae*.

²⁰The problem of the captains seems to have been posed by Ludewijk Huygens in a letter that we do not possess, written after Letter No. 1771. Without a doubt it was about the calculation of the time that will pass until of 40 captains, age 50 years, there die two of them.

²¹Consult No. 1777, where the problem of the captains is treated in this form.

²²Consult, on these problems, No. 1777.

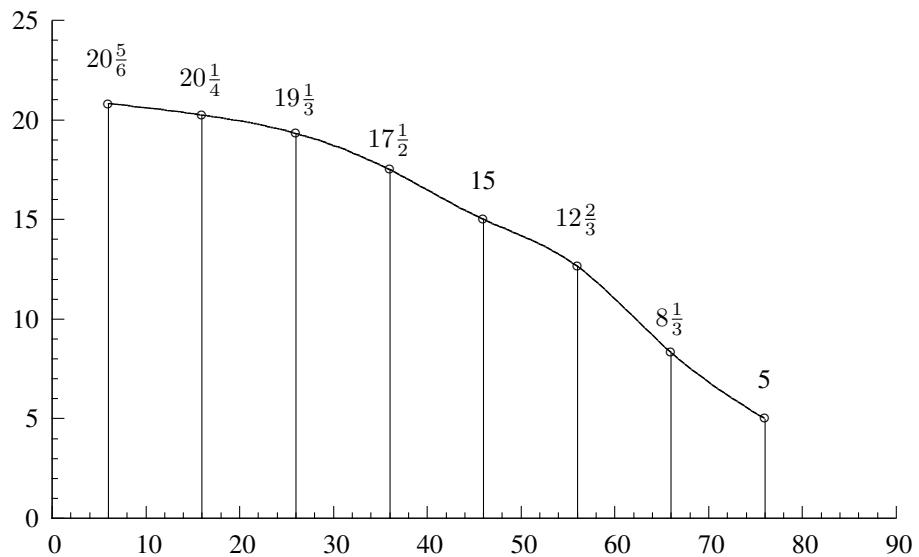


FIGURE 2. No. 1781

solution to the equal ages. The curved line²³ of which I speak in my preceding²⁴ serves only for the wagers, this is why it is not necessary that I send it to you, but one is able to make one of them to supply your table of remainders of life of each age, thus, but in greater volume.²⁵

²³See the plate on page 531.

²⁴Consult Letter No. 1776.

²⁵See the figure at the end of page 538.