FUNCTIONAL MRI STUDY

# Evidence of a Christmas spirit network in the brain

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**Objective** To detect and localise the Christmas spirit in the human brain.

**Design** Single blinded, cross cultural group study with functional magnetic resonance imaging (fMRI).

**Setting** Functional imaging unit and department of clinical physiology, nuclear medicine and PET in Denmark.

**Participants** 10 healthy people from the Copenhagen area who routinely celebrate Christmas and 10 healthy people living in the same area who have no Christmas traditions.

**Main outcome measures** Brain activation unique to the group with Christmas traditions during visual stimulation with images with a Christmas theme.

Methods Functional brain scans optimised for detection of the blood oxygen level dependent (BOLD) response were performed while participants viewed a series of images with Christmas themes interleaved with neutral images. Brain activation maps were compared between groups with and without Christmas traditions to determine Christmas specific brain activation.

**Results** Significant clusters of increased BOLD activation in the sensory motor cortex, the premotor and primary motor cortex, and the parietal lobule (inferior and superior) were found in scans of people with Christmas traditions compared with a group with no such traditions.

**Conclusions** There is a "Christmas spirit network" in the human brain comprising several cortical areas. Although merry and intriguing, these findings should be interpreted with caution.

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## Introduction

We attempted to localise the Christmas spirit in the human brain using functional magnetic resonance imaging (fMRI).

Since its inception in the early 1990s, fMRI has been instrumental in neuropsychological studies localising emotional and functional centres in the human brain. Feelings such as joy, sorrow, and disgust have been isolated to certain cerebral regions.[1] We used a similar technique by comparing a group of people who have celebrated Christmas since their youth with a group having no Christmas traditions. Our hypothesis was that the two groups would respond differently to Christmas images during scanning based on their differences in exposure to Christmas celebrations.

Millions of people are prone to displaying Christmas spirit deficiencies after many years of celebrating Christmas. We refer to this as the "bah humbug" syndrome. Accurate localisation of the Christmas spirit is a paramount first step in being able to help this group of patients.

## Methods

### Participants

The fMRI data in this study were collected as part of the visual paradigm for healthy controls in a previously published migraine study.[2] The study was undertaken in accordance with the Helsinki Declaration as revised in 2008 and was approved by the local ethics committee. All participants gave written and verbal consent to fMRI scanning during visual stimulation. A total of 26 participants were asked to fill out a questionnaire about their Christmas traditions, feelings associated with Christmas, and ethnicity after scanning based on an assumption of their cultural background (box). Participants, and the ethics committee, gave explicit consent to the use of control fMRI data from the study in this article. No eggnog or gingerbread was consumed before the scans.

### Experimental setup

Participants were scanned with MRI while they were watching a series of images through video goggles. A continual series of 84 images were displayed for two seconds each and were organised such that after six consecutive images with a Christmas theme there were six everyday images with similar forms and features though devoid of anything symbolising Christmas (fig 1). The alternating sets of Christmas and everyday images gave an interleaved block stimulation with the time periods where Christmas images are being viewed as "stimulation blocks" interleaved with "resting blocks" of viewing everyday images. Participants were informed that different images would be presented and were not made aware of there being a Christmas theme in the study.

Acquisition of MRI data was carried out on a 3T Philips Achieva (Philips Medical, Best, Netherlands). A $T_1$-weighted MPRAGE sequence was acquired for use as anatomical reference (150 sagittal slices; 1×1×1.1 mm; TR=6.9 ms; TE=2.78 ms; flip angle=9). Functional scans used an echo planar imaging sequence (TR=3 s; TE=35 ms; flip angle=90;

Fig 1 | Four examples from image series viewed by participants, which represent images with and without Christmas theme

### POST-SCAN CHRISTMAS QUESTIONNAIRE

Have you ever celebrated Christmas? (yes/no)

If yes, for how many years?
(option of specifying number of years or answering "every year of my life")

If yes, what are your general feelings about Christmas? (generally positive/generally negative)

Have you lived in Denmark all of your life? (yes/no)

If no, for how long have you been living in Denmark? (option of specifying number of years)

If no, where have you been living before? (option of specifying countries)

What feeling do you associate with Christmas? (free text)

voxel size=1.8×1.8×4 mm; 112 volumes). Cerebral perfusion was imaged with a multi-TI pulsed arterial spin labelling sequence.[3] Seven slices centred at the glabella were acquired to investigate regional perfusion and for use as covariate in the functional general linear model.

We carried out all post-processing, including the creation of brain activation maps, with FSL tools (FMRIB, Oxford) as described by Jenkinson and colleagues,[4] with default settings. With FSL, functional data were motion corrected, spatially filtered with a full width half maximum Gaussian kernel of 5 mm, before we carried out general linear modelling (GLM) with the FMRI expert analysis tool (FEAT). Functional images were spatially normalised to the MNI-152 standard brain. We determined significant clusters of changes in brain activity (changes in BOLD signal) when participants were viewing Christmas images from the z statistical images by a threshold of $z>2.3$ and a (corrected) cluster significance threshold of $P<0.05$. We applied family-wise error correction (FWE). Group comparison based on two sample *t* test was likewise performed with FEAT with default settings. Perfusion measurements were analysed with the QUASIL tool (part of FSL), where we calculated quantification according to Petersen and colleagues.[3] Locations of activation clusters from viewing Christmas images were cross referenced with the Jüelich atlas of the brain in FSL. To evaluate the methods, we previously performed a pilot study in four participants (not included in the current experiment) using a similar design. The preliminary results of this study have been published in Danish.[5]

**Patient involvement**

No patients were involved in setting the research question or the outcome measures, nor were they involved in the design and implementation of the study. There are no plans to involve patients in dissemination.

**Results**

Based on the results of the questionnaire, 10 participants were allocated to the "Christmas group" (eight men, two women) and 10 to the "non-Christmas group" (eight men, two women). The six remaining participants were excluded either because of a strong Christmas connection despite having no tradition of celebrating Christmas (n=2) or non-positive associations with Christmas despite having a cultural background involving regular Christmas celebration. We analysed MRI data only from included participants. Those in the "Christmas group" were ethnic Danes who celebrated Christmas according to Danish tradition, while those in the "non-Christmas group" were Pakistani (n=2), Indian (n=2), Iraqi (n=1), or Turkish (n=2) expatriates or people of Pakistani descent (n=3) who were born in Denmark.

The baseline perfusion scans showed a normal cerebral perfusion of 54 mL/100g/min without any significant difference between the two groups ($P=0.26$). Activation maps from fMRI scans showed an increase of brain activity in the primary visual cortex ($P<0.001$) of both groups when the images viewed had a Christmas theme compared with the everyday images (fig 2). The Christmas group also had significant increases in neural activations in the primary somatosensory cortex when the images had a Christmas theme (fig 2). Comparison of the brain activation maps of the two groups showed five areas where the Christmas group responded to Christmas images with a higher activation than the non-Christmas group (fig 3). These areas of difference include the left primary motor and premotor cortex, right inferior/superior parietal lobule, and bilateral primary somatosensory cortex ($P<0.001$). In contrast, there were no areas of the brain where the non-Christmas group had significantly larger responses to Christmas images than the Christmas group.

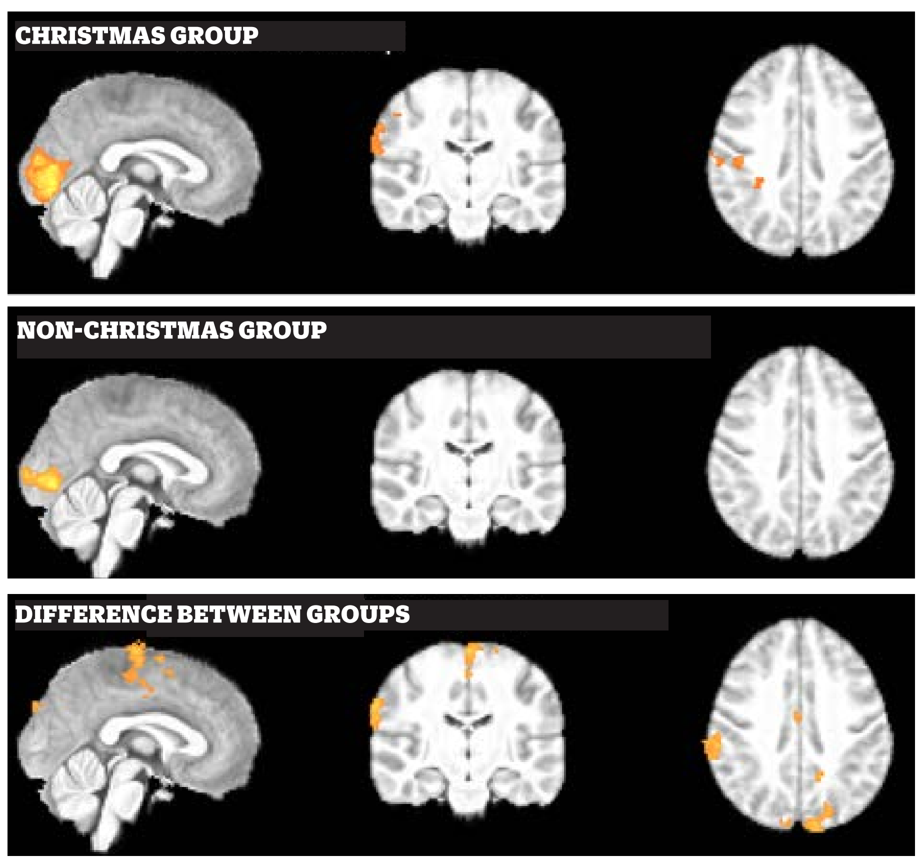


Fig 2 | Activation maps showing areas of significant increases in cerebral activity while participants viewed images with a Christmas theme as opposed to everyday images. Results presented are of a group analysis of participants from the "Christmas group" (top row) and the "non-Christmas group" (middle row). Results of an analysis between groups (bottom row) show that the Christmas group had significantly higher activation (increase in cerebral activity) when viewing Christmas images. Results are shown according to radiological convention—that is, the right side on the coronal and transverse sections represent the left side of the patients and vice versa

## Discussion

There is a cerebral response when people view Christmas images, and there are differences in this response between people who celebrate Christmas compared with those with no Christmas traditions. Cerebral perfusion was similar between the two groups, despite the Christmas group's yearly yuletide feast.

We identified a functional Christmas network comprising several cortical areas, including the parietal lobules, the premotor cortex, and the somatosensory cortex. Activation in these areas coincided well with our hypothesis that images with a Christmas theme would stimulate centres associated with the Christmas spirit. The left and right parietal lobules have been shown in earlier fMRI studies to play a determining role in self transcendence, the personality trait regarding predisposition to spirituality.[6] Furthermore, the frontal premotor cortex is important for experiencing emotions shared with other individuals by mirroring or copying their body state,[7] and premotor cortical mirror neurons even respond to observation of ingestive mouth actions.[8] Recall of joyful emotions and pleasant ingestive behaviour shared with loved ones would be likely to elicit activation here. There is growing evidence that the somatosensory cortex plays an important role in recognition of facial emotion and retrieving social relevant information from faces.[9] Collectively, these cortical areas possibly constitute the neuronal correlate of the Christmas spirit in the human brain.

We realise that some of our colleagues within the specialties of neuroscience and psychology, who we suspect could be afflicted by the aforementioned bah humbug syndrome, would argue that studies such as the present one overemphasise the importance of localised brain activity and that attempts to localise complex emotions in the brain contribute little to the understanding of these emotions. Citing a paper reporting fMRI evidence of brain activity in frozen salmon,[10] representatives of this view have even coined terms for this practice such as "blobology," "neo-phrenology," "neuro-essentialism," and "neuro-bollocks" (Grinch and colleagues, personal communication). Naturally, in keeping with the good spirit of the holiday, we disagree with these negative perspectives.

## Limitations

Our study design doesn't distinguish whether the observed activation is Christmas specific or the result of any combination of joyful, festive, or nostalgic emotions in general. The paired Christmas/non-Christmas pictures might have been systematically different in a way that we were not aware of—for example, the "Christmas pictures" containing more red colour. Maybe the groups were different in other ways apart from the obvious cultural difference. Given these uncertainties and the risk of false positive results, our findings should ideally be reproduced before firm conclusions are drawn.

Further research into this topic is necessary to identify the factors affecting one's response to Christmas. For example, responses to Christmas might change with development from a child, who primarily receives presents, to an adult, who primarily buys them. Subgroups subjected to receipt of tacky jumpers as their Christmas present might also have different responses in brain activity from those of subgroups who tend to receive more attractive gifts. Understanding how the Christmas spirit works as a neurological network could provide insight into an interesting area of human neuropsychology and be a powerful tool in treating ailments such as bah humbug syndrome. Comparative studies of these patterns will also be imperative in studying other seasonal disturbances, related to, for example, Easter, Chanukah, or Diwali. This study could therefore be an important first step in transcultural neuroscience and the associations humans have with their festive traditions.

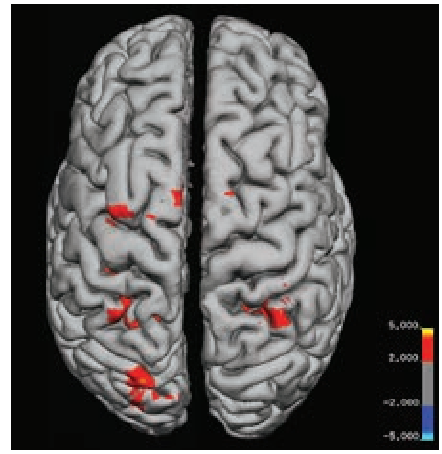

Fig 3 | Cerebral areas where the "Christmas group" had a significantly higher increase in cerebral activity than the "non-Christmas group" while images viewed had a Christmas theme. The color scale is of z values representing response of "Christmas group" relative to "non-Christmas" as a control group

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## CERTIFICATE IN REVERSE PSYCHOLOGY

After reviewing a large amount of data we have concluded that you probably don't want to apply for the official certificate in Reverse Psychology, even though the fee is so reasonable that you won't believe it. If the application materials meet clearly defined criteria, you will receive an authentic certificate with two signatures that are not written by the same person, once with the right hand, once with the left. Stamped by Notor Republic. Whatever you do, do not send money to the corresponding author to learn how to apply for this exclusive opportunity today. Your patients do not want you to learn about this simple secret, and it's probably not worth it.

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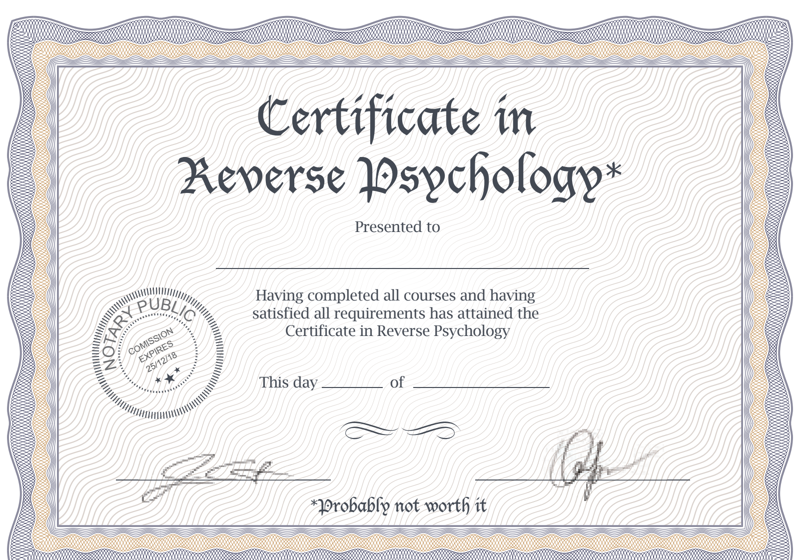

HISTORICAL COHORT STUDY

# Debunking the curse of the rainbow jersey

Thomas Perneger

**Objective** To understand the underlying mechanism of the "curse of the rainbow jersey," the lack of wins that purportedly affects the current cycling world champion.

**Design** Historical cohort study.

**Setting** On the road.

**Participants** Professional cyclists who won the World Championship Road Race or the Tour of Lombardy, 1965-2013.

**Main outcome measures** Number of professional wins per season in the year when the target race was won (year 0) and in the two following years (years 1 and 2; the world champion wears the rainbow jersey in year 1). The following hypotheses were tested: the "spotlight effect" (that is, people notice when a champion loses), the "marked man hypothesis" (the champion, who must wear a visible jersey, is marked closely by competitors), and "regression to the mean" (a successful season will be generally followed by a less successful one).

**Results** On average, world champions registered 5.04 wins in year 0, 3.96 in year 1, and 3.47 in year 2; meanwhile, winners of the Tour of Lombardy registered 5.08, 4.22, and 3.83 wins. In a regression model that accounted for the propensity to win of each rider, the baseline year accrued more wins than did the other years (win ratio 1.49, 95% confidence interval 1.24 to 1.80), but the year in the rainbow jersey did not differ significantly from other cycling seasons.

**Conclusions** The cycling world champion is significantly less successful during the year when he wears the rainbow jersey than in the previous year, but this is best explained by regression to the mean, not by a curse.

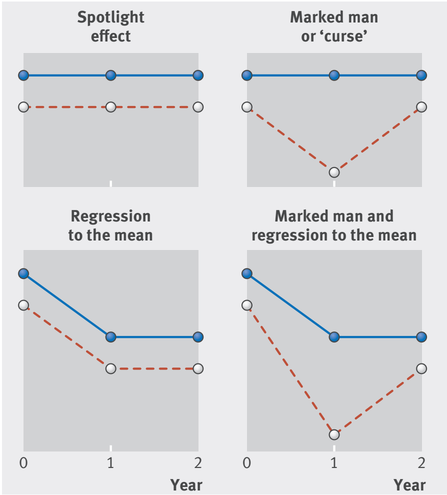


**Fig 1** | **Three hypotheses under consideration: expected average number of wins in year when race took place (year 0), following year (year 1), and year after that (year 2), for winner of World Championship Road Race (open circles) and winner of Tour of Lombardy (solid circles)**

## Introduction

Samuel Johnson chided doctors for believing that if a patient got better it was because they sent him to the waters, for mistaking "subsequence for consequence."[1] The alternative explanation—that patients consult when they feel poorly, and most get better regardless of treatment—requires a grasp of random variation.

Doctors are not the only culprits. Consider professional cycling and the "curse of the rainbow jersey."[3] The "rainbow" jersey is worn by the current cycling world champion. In 1965 British cyclist Tom Simpson won the World Championship Road Race, then broke his leg while skiing during the following winter and lost his 1966 season to this and other injuries. In the ensuing years, champion after champion encountered all manner of misery while wearing the jersey: injury, disease, family tragedy, doping investigations, even death, but especially a lack of wins.[3]

One explanation is that the world champion is as likely to encounter difficulties as anyone, but, as he is the champion, people notice more. This is the "spotlight effect." Another is that the world champion is marked more closely by rivals, which lowers his chances of winning. This is the "marked man hypothesis." Finally, random variation in success rates ensures that a very successful season is likely to be followed by a less successful season. This is the "regression to the mean" phenomenon.[4] In this study, I explored to what extent these hypotheses are supported by racing results of cycling champions.

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## Methods

The study population included winners of the Union Cycliste Internationale men's World Championship Road Race from 1965 to 2013 and, for comparison, the winners of the Tour of Lombardy of the same years. The latter race is of comparable importance—it is one of five "monuments" among classic one day races—and takes place at the end of the racing season, just like the World Championship.

The outcome variable was the number of individual wins in professional races during a given year, obtained from a publicly accessible database (www.procyclingstats.com). Win counts were obtained for three calendar years: year 0, at the end of which the rider won the target race (World Championship or Tour of Lombardy); year 1, during which the world champion wore the allegedly cursed jersey; and year 2, when all riders returned to curse-free status.

The pattern of wins characterising the three hypotheses are given in figure 1.

Mark Cavendish, 2011 road world champion

Table 1 | Mean number of professional racing wins for world champions and for Tour of Lombardy winners of preceding year

| | No of rider years | Mean (SD) No of wins | Quartiles | P value *v* year 0* | P value *v* year 1* |
|---|---|---|---|---|---|
| World champions | | | | | |
| Year 0 | 49 | 5.04 (4.32) | 2, 3, 6 | – | 0.021 |
| Year 1† | 49 | 3.96 (5.61) | 1, 2, 5 | 0.021 | – |
| Year 2 | 46 | 3.47 (5.18) | 1, 1, 5 | 0.011 | 0.53 |
| Lombardy winners | | | | | |
| Year 0 | 49 | 5.08 (4.04) | 2, 4, 7 | – | 0.030 |
| Year 1 | 49 | 4.22 (4.94) | 1, 2, 5 | 0.030 | – |
| Year 2 | 47 | 3.83 (4.55) | 1, 3, 5 | 0.004 | 0.34 |

* Wilcoxon paired test.
† Corresponds to the year during which the "curse of the rainbow jersey" applies.


The current road racing world champion wins less on average than he did in the previous season

Table 2 | Mixed negative binomial regression models with random rider specific intercept, and their goodness of fit statistics

| | Model 1: Spotlight effect | | Model 2: Marked man or rainbow curse | | Model 3: Regression to mean | | Model 4: Marked man and regression to mean | |
|---|---|---|---|---|---|---|---|---|
| Hypothesis represented | Ratio (95% CI) of wins | P value | Ratio (95% CI) of wins | P value | Ratio (95% CI) of wins | P value | Ratio (95% CI) of wins | P value |
| Lombardy (*v* worlds) | 1.10 (0.85 to 1.42) | 0.46 | 1.05 (0.80 to 1.37) | 0.74 | 1.10 (0.86 to 1.42) | 0.79 | 1.14 (0.87 to 1.49) | 0.34 |
| Rainbow year (*v* all others) | – | – | 0.86 (0.65 to 1.13) | 0.28 | | – | 1.10 (0.82 to 1.47) | 0.53 |
| Baseline year (*v* year 1 or 2) | – | – | – | – | 1.49 (1.24 to 1.80) | <0.001 | 1.53 (1.25 to 1.87) | <0.001 |
| Akaike information criterion* | 1389.36 | – | 1390.18 | – | 1373.10 | – | 1374.70 | – |

* Lower value is better.

### Statistical analysis

I tabulated the mean numbers of professional victories per rider and per year separately for winners of the World Championship and of the Tour of Lombardy. I used the Wilcoxon paired test for year to year comparisons.

I used mixed negative binomial regression to evaluate the hypotheses.[5] The dependent variable was the annual number of wins. Each rider was afforded an individual tendency to win, represented below by the random intercept $\alpha_i$. The index "i" identified the rider and remained identical if a rider won more than one target race (for example, Eddy Merckx won five target races and contributed 15 data points). An annual win count appeared more than once if it counted towards more than one target win; for example, for a repeat champion, the win total for year 1 of the first title was also the win total for year 0 of the second title. Four models were built (see thebmj.com for details).

### Results

The dataset included annual win totals for 289 rider years: for each race, 49 results in year 0, 49 in year 1, and 46 (World Championship) or 47 (Tour of Lombardy) in year 2. Totals were lower in year 2 because winners in 2013 contributed only years 0 and 1 (the 2015 season was incomplete at the time of analysis), and three win totals were missing due to retirement of riders. Several riders won more than one target race, and 63 different riders contributed data: 40 riders had one target win, 14 had two wins, seven had three wins, one had four wins, and one had five (Merckx, triple world champion and double Lombardy winner). Six riders won both races in the same season.

Winners of both target races had similar annual numbers of wins: on average 4.18 (quartiles 1, 2.5, and 5) for world champions, and 4.37 (quartiles 1, 3, and 6) for Lombardy winners. Similarly, for winners of both races, the annual win total was higher in year 0 than in years 1 and 2 (table 1); the difference between year 0 and the following years was statistically significant, but the difference between years 1 and 2 was not.

The first regression model confirmed that the average number of annual wins did not differ significantly between world champions and Lombardy winners (table 2). Model 2 tested whether the year in the rainbow jersey was a special case; although the win ratio was less than 1, the reduction was small and statistically non-significant. Model 3 confirmed that the baseline year of both races was significantly more successful than the ensuing years. Model 4 confirmed that the rainbow year did not differ significantly from other years (this time the win ratio was above 1) but that the baseline year of either race was significantly more successful.

The comparison of goodness of fit statistics confirmed that models 3 and 4, which incorporated regression to the mean, were substantially better than models 1 or 2. The best fitting model was model 3, as it had the lowest value of the Akaike information criterion.

### Discussion

The curse of the rainbow jersey probably does not exist. The current road racing world champion wins less on average than he did in the previous season, but this phenomenon is best explained by regression to the mean. The relative lack of success was not restricted to the season in the rainbow jersey but persisted in the following season and affected equally the winners of the Tour of Lombardy.

Nevertheless, this study may not rule out a curse entirely, as it tested only one facet of the curse—the decrease in wins. I found no good data about the personal problems of professional cyclists. Also, all wins were given even weight: if the world champion is cursed to winning only minor races, this analysis would have missed that. Finally, this analysis did not account for any changes in doping practices, for lack of reliable data.

Regression towards the mean is unavoidable whenever the variable under study (here, sporting success) fluctuates over time, the correlation between consecutive observations is less than 1, and the baseline observation is defined by an arbitrarily high or low value (here, a season marked by an important win). Regression to the mean may explain, for instance, why patients who lose bone density in the first year are likely to reverse this trend at follow-up or why HIV related risk behaviours improve after enrolment into a prevention trial.[7 8] Quite possibly, the proverb "Pride goeth before destruction" (King James Bible, *Proverbs* 16:18) should be credited with the first description of regression towards the mean, and not Francis Galton,[9] who merely showed that chance and correlation, not the Lord or a large ego, were to blame.

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