

Origins of magic: review of genetic and epigenetic effects

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BMJ 2007;335:1299-301

doi:10.1136/bmj.39414.582639.BE

Accepted: 16 November 2007

ABSTRACT

Objective To assess the evidence for a genetic basis to magic.

Design Literature review.

Setting Harry Potter novels of J K Rowling.

Participants Muggles, witches, wizards, and squibs.

Interventions Limited.

Main outcome measures Family and twin studies, magical ability, and specific magical skills.

Results Magic shows strong evidence of heritability, with familial aggregation and concordance in twins. Evidence suggests magical ability to be a quantitative trait. Specific magical skills, notably being able to speak to snakes, predict the future, and change hair colour, all seem heritable.

Conclusions A multilocus model with a dominant gene for magic might exist, controlled epistatically by one or more loci, possibly recessive in nature. Magical enhancers regulating gene expression may be involved, combined with mutations at specific genes implicated in speech and hair colour such as FOXP2 and MCR1.

INTRODUCTION

Genetic factors that underlie traits such as height¹ and weight² are currently under scrutiny using genome wide association methods, yet the detection of genes predisposing to magic has been given relatively short shrift. Using the books by J K Rowling about Harry Potter, a schoolboy wizard, to gain an insight into humans with magical abilities, one study suggested that magic is the result of a single gene.³ This assertion has been contentious, however, with another study questioning whether magic is heritable.⁴ We assessed the heritability of magic now that the Harry Potter series is complete with the publication of the seventh and final book.⁵

According to the Harry Potter books⁵⁻¹¹ most people in the world are muggles—that is, possess no magical ability—whereas a minority are witches and wizards with magical abilities. Rarely we are introduced to squibs, offspring resulting from the non-transmission of magic within a family with magical abilities. Compared with muggles squibs have some magical ability, as they can see and interact with the magical world.

When considering the genetics of magic we need to be able to explain several observations. Firstly,

matings between humans with magical abilities produce offspring with magical abilities, rarely squibs, and not muggles. Secondly, matings between humans with magical abilities and muggles seem to always produce offspring with magical abilities. Thirdly, matings between muggles produce either muggles or, rarely, offspring with magical abilities and never squibs. Finally, parent of origin effects are not apparent—examples exist of wizards with muggle father and wizard mother parentage and vice versa.

METHODS AND RESULTS

We used the Harry Potter novels by J K Rowling⁵⁻¹¹ as original source material to identify characters from the magical and non-magical world—namely, muggles, witches, wizards, and squibs (see glossary)—their magical abilities, and familial relationships. To avoid factual errors, different members of the team carried out repeated readings of the novels and listened to unabridged audio productions of the books.

Magical family lineages

Firstly, we estimated familial aggregation to detect whether a characteristic has a genetic component.¹² The final Harry Potter book *Harry Potter and the Deathly Hallows*⁵ goes into great detail about magical families, notable examples being the Black and Gaunt lineages. Only one example of the non-transmission of magic is described, resulting in a squib offspring. Although shared environmental influences can also lead to familial clustering of a trait, the presence of magical abilities in seven generations of the Black family and at least three generations in others strongly suggests the influence of genetic factors in determining magical ability. This might also be true for non-human magical creatures—for example, the house elf Kreacher and his ancestors who have served the Black family for generations.

Twin studies

Although assumptions are made, complete genetic determination of a disease would result in monozygotic twins being concordant.¹² The two pairs of twins in the Harry Potter books, the Patil and Weasley twins, are monozygotic and both have magical abilities. Although two sets of twins is a small sample size,

the finding does add credence to the idea of magic being a genetically determined trait.

Quantitative traits

Magic is not a dichotomous trait; we prefer the idea of magical ability, a quantitative attribute, ranging from the talents of Albus Dumbledore, Harry’s headmaster at Hogwarts School of Witchcraft and Wizardry, to the relative ineptitude of Crabbe and Goyle, the sidekicks of Harry’s nemesis Draco Malfoy. Magical ability also seems to be genetically determined, with familial aggregation highlighted by the Weasley twins who seem equally matched in aptitude, and the magical abilities of Harry Potter. Harry was raised by muggles after the death of his magical parents, James and Lily Potter, before his first birthday; although James and Lily were outstanding wizards, exemplified by their role as head boy and head girl at Hogwarts school, the environment of 4 Privet Drive where Harry lived with his muggle relatives, the Dursley family, could not have been further removed from the magical world. This situation would be similar to an adoption study, the most powerful way of disentangling genetic influences from those of the environment.¹² Variation in a quantitative trait usually results from the contributions of multiple genes, with small effects modified by environmental influences.¹³ Magical ability is likely to be affected by the environment, with experience and emotional state being important factors.

Single gene effects

In the spectrum of magical ability three skills seem likely to be conferred by specific genes. One of these skills is speaking to snakes (parseltongue), known to be a feature of only direct descendants of Salazar Slytherin, one of the four founders of Hogwarts school. Another skill is clairvoyance. Sybill Trelawney, a professor of divination at Hogwarts school, is a seer and so was her great great grandmother. Lastly, Nymphadora Tonks, a character in the fifth Harry Potter book *The Order of the Phoenix*, was able to change her physical appearance (a metamorphmagus) and so was her son.

Founder effects

As most magical communities are isolated, high rates of inbreeding and assortative mating (see glossary) are possible, resulting in lower genetic variation for the magical population (that is, a founder effect).¹⁴ This might be partly why magical ability seems to be passed on from generation to generation without fail in matings between humans with magical abilities. The exception to this would be offspring who are squibs. The heritability of the squib phenotype is unknown as no matings between squibs have been described. Matings between muggles and magical folk always seem to result in offspring with magical abilities, suggesting that a dominant gene is at play. The relative frequency of offspring with magical abilities in matings between muggles argues against a simple dominant gene effect. This could be explained, however, if muggles with magical abilities are those descended from squibs in previous generations who have integrated into muggle society.

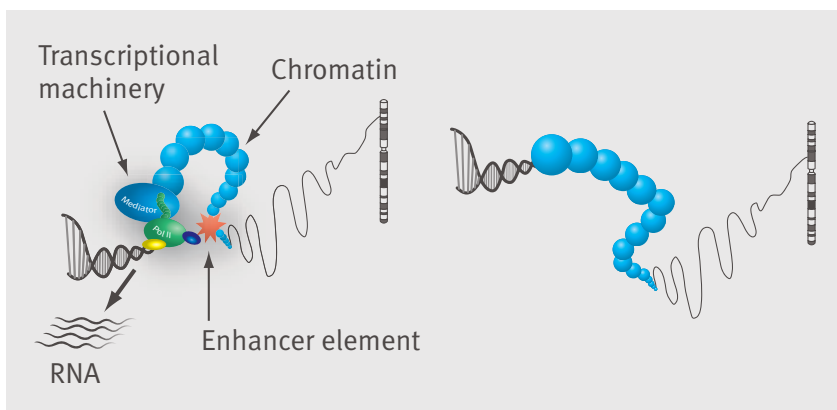
DISCUSSION

The observed inheritance of magic in the Harry Potter books by J K Rowling would be best explained by a multilocus model with a dominant gene for magic, the function of which is controlled epistatically by one or more other loci,¹⁵ possibly recessive in nature. The genotypes of the loci concerned influence total magical ability, and the allele frequencies of these magical loci would differ significantly between populations with magical abilities and those without (muggles). We cannot yet confirm this finding, however, as those with magical backgrounds have not been included in the International HapMap project.¹⁶ Genetic heterogeneity may exist.

Magical enhancers and candidate genes

We hypothesise that a profound mutation in an evolutionary ancestor occurred in a histone gene, which radically altered genome wide chromatin structure. This created new sites of chromatin accessibility and altered gene regulation, including novel enhancer elements to drive “magical” type expression of genes (figure). Such magical enhancers would join a growing list of regulatory elements such as promoters, enhancers, silencers, insulators, and locus control regions.¹⁷ These regulatory elements are currently being identified and catalogued by the Encyclopedia of DNA Elements (ENCODE) Project Consortium, with analysis of 1% of the human genome recently reported.¹⁸ A dominant mutation in the histone gene could provide heritability of this epigenetic effect.¹⁹ Such a mechanism originating in our ancestors would account for non-human magical creatures with some magical abilities (for example, house elves, goblins, centaurs). The basic human genetic structure still develops, making wizards and witches in most ways phenotypically similar to muggles. Squibs may result from an as yet unidentified compensatory epigenetic phenomenon, which returns the chromatin to near normal (muggle) function.

If DNA sequence variants arise on this background then the capacity for magical expression of genes may differ between wizards. For example, given the reported



Left: Magical enhancer element within a site of accessible chromatin in human with ancestors all possessing magical abilities (pureblood), which interacts with transcriptional apparatus to drive gene expression. Right: Chromatin in non-magical human (muggle) remains in an inactive closed conformation

WHAT IS ALREADY KNOWN ON THIS TOPIC

Magical abilities may be heritable
Complete family lineages to study this topic have only recently become available

WHAT THIS STUDY ADDS

Some aspects of magical ability have a genetic basis
This is not a simple single gene effect and may be related to “magical enhancer” elements

association between genes and speech and language, further mutations at the *FOXP2* gene²⁰ could account for the rare magical ability to speak to snakes (parseltongue), whereas variants at the *MC1R* gene may explain Nymphadora Tonks's ability to change her hair colour. The *MC1R* gene encodes the melanocortin-1 receptor, which is involved in regulation of pigmentation.²¹ This gene is known to be highly polymorphic and variants have been associated with differences in hair colour.²¹ *NF2* is another candidate gene for magic. *NF2* encodes Merlin, the moesin ezrin radixin related protein, and mutations within this gene could lead to magical effects consistent with the known role of Merlin in coordinating multiple cellular signalling events.²² However, anything acting upstream of Hippo and Warts kinases would not, we feel, meet with the approval of such magical luminaries as Albus Dumbledore, the headmaster of Hogwarts school.

Without population based studies to confirm our points these findings should be treated with caution, but using the information available we can be certain that some aspects of magical ability are heritable. We await with bated breath the results of a genome wide association study for magic.

We thank the three underage witches who gave specialist advice on more technical aspects of the Harry Potter novels and David Dymont, Blanca Herrera, Emma Walton, and Claire Vandiedonck for helpful comments.

Contributors: JCK and MK conceived the study. JCK designed the study and is the guarantor. All authors analysed and interpreted the data and wrote the paper.

Funding: SVR is funded by the Medical Research Council of the United Kingdom. MK is funded by a postdoctoral award from the Department of Health National Coordinating Centre for Research Capacity Development. GCE is the action research professor of clinical neurology at the University of Oxford. JCK is a Wellcome Trust senior research fellow in clinical science. The National Perinatal Epidemiology Unit is funded by the Department of Health in England. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Department of Health.

Competing interests: None declared.

Ethical approval: Not required.

Provenance and peer review: Not commissioned; externally peer reviewed.

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GLOSSARY

Assortative mating—people tending to mate with others like themselves

Chromatin—complex of DNA and protein that constitute chromosomes

Epigenetics—heritable changes in gene function not involving changes in DNA sequence

Epistasis—action of one gene modified by another

Founder effect—increase in gene frequency when a population has only a small number of original settlers (founders), one or more of whom had that gene

HapMap project—haplotype (series of correlated alleles) map of the human genome, currently being analysed in populations of African, Asian, and European ancestry

Histones—main protein components of chromatin

House elves—human-like creatures with distinctive magical abilities who are bound to, and act as servants for, several magical families

Metamorphmagus—someone with the ability to change their physical appearance

Muggle—someone with no magical abilities

Parseltongue—ability to talk to snakes

Pureblood—someone whose ancestors all possess magical abilities

Seer—someone who can predict the future

Squib—someone with virtually no magical abilities who comes from a magical family