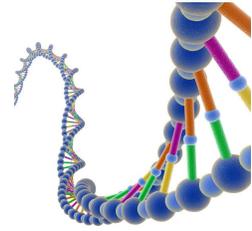


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## Psychological Consequences of Personal Genomics

### BACKGROUND

When it comes to personalized disease treatment, what just a couple decades ago seemed like science fiction is now quickly becoming a reality. The Human Genome Project, begun in 1990 and completed in 2003, set in motion a revolution in disease diagnosis and treatment. The BRCA1 and BRCA2 genes were some of the earlier genes to be isolated as factors in a disease, and the role they play in the formation of breast cancer is now well-publicized, showing that looking to an individual's genome to assess their susceptibility to diseases is becoming ever more customary. The first successful genome-wide association (GWA) study was done in 2005, and since then this research has become commonplace. New single-nucleotide polymorphisms (SNPs) and other genetic mutations are being linked to all kinds of phenotypic traits, from cancer to facial structure to intelligence. The benefits of this increased knowledge are indisputable, but there are also great risks associated with personal genomics. The possible legal ramifications and the potential for genetic discrimination are often the topics of discussion; the Genetic Information Nondiscrimination Act of 2008 took steps to protect individuals from insurance and employment discrimination based on their genetic information. Less often, though, do people study the potential negative psychological effects of knowing extensive details of one's personal genetic predispositions. It's quite possible that as people become more physically healthy they will also become more psychologically disturbed, preoccupied by their genetic shortcomings.

### UNTREATABLE CONDITIONS AND DEPRESSION

When talking about psychological risks of personal genomics, researchers usually focus on the burden of knowing that you are at increased risk of getting a disease when there is not much that can be done to prevent it. For some diseases with genetic components, such as breast and prostate cancer for instance, there is little an at-risk individual can do to reduce their risk. Now, in the case of lung cancer, much can be done. Someone who knows he is predisposed to lung cancer can greatly reduce his risk by avoiding cigarette smoke. It can be argued, however, that this isn't a benefit that comes from personal genomics, because this is already commonly done by looking at family history to suggest predispositions. One could even say that someone who has a familial history of lung cancer but whose genome suggests that he is at reduced risk would be more inclined to partake in risky behaviors than he would have been without that personal genetic knowledge. Clearly, issues surrounding personal genomics are very hazy, and there is a fine line between the benefits and detriments of choosing to sequence.

It's possible that knowing too much about your risks when genome/disease associations are accumulating faster than successful treatment methods is hazardous to the mental health of those who choose to be sequenced. A radio interview on NPR (Palca, 2010) discussed the complications surrounding genomics with a Stanford law professor, and briefly touched on psychological ramifications. As the host suggested, "[Genome sequencing] might be useful, but it might also give you a lot to worry about. If your genes say you have a predisposition to an incurable disease like Alzheimer's, do you really want to know that?" This fear is supported by multiple cases, including a study from 2001 in which adults showed increased levels of anxiety and depression after testing positive for a gene associated with developing colon cancer (Michie et al).

Children in the 2001 study did not show any increased levels of anxiety after testing positive for colon cancer risk, but there are other, special concerns associated with children. Many studies have been done since the later half of the 20<sup>th</sup> century on self-fulfilling prophecies (Pygmalion effect) in the classroom, many of which support the idea that expectations of a child's success, no matter how unfounded, contribute subconsciously to the teacher's treatment of this child, which in turn affects how motivated the student is and how well they learn the material. Observational studies of this effect often do not offer substantial data because teachers in a normal setting make inferences about a child's promise based on accurate information they get from interacting with the student (see Jussim et al). In an experimental setting (of questionable ethics), however, the Pygmalion effect is more pronounced. Rosenthal and Lenore did an experiment in 1968 that showed that when elementary school teachers are told that certain students demonstrate unusually high promise (exceptionally bright), while others demonstrate unusually low promise (exceptionally dull), this "knowledge," though completely unfounded, led the teachers to subconsciously give more attention and favor to the "bright" students and these students did end up learning better than the "dull" group and demonstrating higher intelligence. This, and other experiments like it, demonstrate the powerful effect of expectations on a child's development.

This is a very serious concern when it comes to personal genomics. It is not unreasonable to think that, relatively soon, genome sequencing at birth will become common. First, perhaps, for those families that have a history of certain diseases, and then for everyone as our technology and knowledge of genetic associations with specific traits develop. Genome sequencing does, after all, present the fantastic advantage of early diagnosis and early intervention. But it can offer much more than disease diagnosis and risk calculation. GWA studies have been performed for all

kinds of traits, from alcoholism to criminal tendencies, psychopathy, and intelligence, thus linking certain genetic patterns to a variety of nonphysical traits. In 2011 a research group in the UK performed a GWA study looking for genetic markers associated with high versus low cognitive ability (Davies et al). They estimated that approximately 41% of crystallized intelligence (ability to recall knowledge and skills in the long term) can be accounted for by genetic variation, and about 50% of fluid intelligence (ability to think critically and apply logic in novel situations) can be accounted for this way. Another GWA study on intelligence, this time focusing on individuals with ADHD, found many genetic loci that are correlated with higher intelligence (Loo et al). For example, the gene KIF16B was strongly associated with intelligence, with a very low p-value suggesting that the result is highly meaningful. This makes sense when we see that this gene is involved in synaptic signaling and transport between neurons. They found that intelligence is extremely polygenic — something to be expected — but that there is much potential for finding the genes that influence it. The eight genes this study found account for about 8% of variation in intelligence, suggesting that there's much room for other researchers to continue this work and find more associated genes.

As we can see, there's much more to personal genome sequencing than just disease diagnosis, and we already discussed how it is likely that genetic sequencing at birth (even in some cases before birth, in prenatal testing) will become commonplace. So, when our knowledge expands and every parent knows from their child's birth what diseases, behaviors, physical features, and psychological traits (like intelligence) the child is predisposed to, this is very likely to influence their treatment of the child in subconscious — but powerful — ways. We can turn to many studies that demonstrate a link between motivation (including that from outside sources, like parents) and a child's ability to learn. We can extrapolate from these studies how a child will

react if she is raised with very different expectations from her sibling (perhaps because her sibling's genome shows more tendencies toward athletic skill, or more promise in intelligence). While it is unfortunate when two siblings are treated differently on traits even today, when two siblings may be in grade school together and it becomes apparent that one is a star athlete or is greatly gifted in school while the other is much less so, this will take on a whole new level when parents expect different things and raise their children even subtly different from the time each child is born.

Many studies have characterized "adaptive" and "maladaptive" patterns of achievement behavior, and some of these results are cited and summarized in a paper by Carol Dweck (1986). The adaptive pattern is characterized by challenge-seeking and high persistence in the face of obstacles, whereas the maladaptive pattern is characterized by challenge-avoidance and very low persistence when met with difficulties. The maladaptive pattern is associated with a failure to establish reasonable, valued goals and to maintain the motivation to strive for those goals. People with this behavioral pattern ultimately fail to achieve valued goals that are potentially within their reach. The author notes that these differences are not associated with any inherent intellectual differences, but with pronounced differences in cognitive performance, perhaps suggesting that these differences are more environmental than genetic, because the difference lies in their approach to difficulties rather than in their inherent ability to overcome them.

For a practical application of these findings to genomics, say that between newborn fraternal twins, one shows genetic markers for higher cognitive ability and the other shows average ability. The parents then expect more from Twin 1, and despite their efforts to treat both equally, the way they raise them reflects a subconscious impact made by knowledge of the twins' genetic markers (in much the same way that altering teachers' perceptions of students

subconsciously influences how they treat them). For instance, when Twin 1 gets a “B-” on a project, the parents are disappointed and the child realizes that they expect more from him. When Twin 2 gets a “B-” on a comparable assignment, the parents do not express disappointment and the child realizes that more is not expected from him. We can see how Twin 1 would be likely to develop the adaptive strategy and demonstrate a good amount of intrinsic motivation in the face of obstacles later in life, because his parents subtly pushed him to achieve more and do better during his adolescence. Twin 2, on the other hand, would be predisposed to the maladaptive pattern because he has a subconscious understanding that average is all he can achieve, so fighting to overcome difficulties is futile. It is not unreasonable to suggest that in this situation, the genetic differences between the twins may have had only a slight effect on potential intelligence, but the differences became accentuated through the parents’ treatment of the twins and ultimately one shows higher cognitive capacity because more was expected from him. When the twins are old enough to know and understand their genomes, they will see these differences in intellectual markers and assume they are the cause of their phenotypic differences, thus justifying their respective cognitive abilities as traits outside of their control. We can see how this same effect of motivational and expectational differences could be applied, not only to intelligence and cognitive functioning (on which there is a good amount of literature), but to other psychological and behavioral traits as well, like criminal tendencies, risk-seeking behaviors (predisposed to reckless driving and other dangerous activities), and so on. As uncommon as it is for researchers to study how genome sequencing could negatively impact children’s upbringings in this way (simply because this wasn’t even a realistic possibility until recently), a report formed by an early committee on genomic research and ethics in the UK specifically discussed the special effects genome testing could have on children, including the potential “Pygmalion effect”

(Clarke, 1994). The researchers shared my concerns, hypothesizing, “the parents' attitudes to the child may change, and that unfavourable parental expectations about a child's future mental, physical, and emotional development could be self-fulfilling.”

#### CONCLUDING THOUGHTS

There is much that can be said about personal genomic's potential to negatively impact the psyches of individuals and the overall mental health of our modern societies. The anxiety and depression that can be caused in a teen when she finds out that she carries the gene for Huntington's, or the worry that arises in children when a parent tests positive for a disease that has a heritability of 50% are certainly very serious problems, and genetic counselors are becoming more common as interested people discuss the risks and benefits of determining their predispositions to disease. To my mind, however, the question of how — once genome sequencing becomes customary and more links between genes and phenotypic traits are being documented every day — having knowledge of one's personal phenotypic predispositions or those of his or her children will affect the psychology of sequenced individuals, including how they perceive personal worth and abilities. This is where I see the gray area of personal genomics. It's hardly contestable that early disease intervention would be greatly aided by widespread personal genome sequencing. Additionally, the concerns about anxiety may be misplaced, as many studies suggest that it's equally harmful to fear that you could be at risk, but not know for certain. In fact, some studies find that psychological torment decreases, even after testing positive for a fatal disease (see Lerman, 1998 and Perry, 1990). And, of course, there's the laymen's perspective, which is represented in the NPR interview with the law professor (Palca, 2010). A caller with a family history of cancer, identified as Willy, spoke about the dark cloud of uncertainty that is always hanging over him and offered this perspective on sequencing:

And, you know, [genome sequencing] could save me [from] this vague idea that someday I'll die of cancer and I should take care better of myself.

So I love the idea of it. I haven't thought through all the potential negative repercussions. But I can't think of anything that would outweigh the idea that I might survive.

While it may be disconcerting to hear that an interested individual has not thought through all the potential negative consequences of sequencing (a concern that will keep genetic counselors in business), it's hard to argue with the man's closing sentiment. So perhaps we should accept that, like it or not, genome sequencing will be used frequently in the near future to test for disease risk, and shift our focus more to the potential psychological consequences for our society when sequencing does become common and suddenly we are all born with a genetic blueprint, an oracle for what to expect from ourselves, in our hands.

#### References

- Clarke, A. The Genetic Testing of Children. *J Med Genet.* 1994 October; 31(10): 785–797. Web. 4 Dec. 2012. <<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1050126/pdf/jmedgene00289-0045.pdf>>.
- Conger, Krista. "The Genome Is Out of the Bag: Now What?" *Stanford Medicine* vol. 27, #3 (Fall 2010): 8-15, 43. *StanMed.Stanford.edu*. Stanford University School of Medicine, Fall 2010. Web. 4 Dec. 2012. <<http://stanmed.stanford.edu/2010fall/article1.html>>.
- Davies, Gail, et al. "Genome-wide association studies establish that human intelligence is highly heritable and polygenic." *Molecular psychiatry* 16.10 (2011): 996-1005. Web. 4 Dec. 2012. <<http://www.nature.com/mp/journal/v16/n10/abs/mp201185a.html>>.

- Deci, Edward L., et al. "Motivation and education: The self-determination perspective." Educational psychologist 26.3-4 (1991): 325-346. Web. 4 Dec. 2012. <[http://www.selfdeterminationtheory.org/SDT/documents/1991\\_DeciVallerandPelletierRyan\\_EP.pdf](http://www.selfdeterminationtheory.org/SDT/documents/1991_DeciVallerandPelletierRyan_EP.pdf)>.
- Dweck, C. S. Motivational processes affecting learning. American Psychologist, 41(10), (1986): 1040-1048. Web. 4 Dec. 2012. <<http://psycnet.apa.org/journals/amp/41/10/1040.html>>.
- Greely, Henry T. "Legal, Ethical, and Social Issues in Human Genome Research." Annual Review of Anthropology (1998): 473-502. Web. 4 Dec. 2012. <<http://homes.chass.utoronto.ca/~cline/phl283s2003/Greely%201998.pdf>>.
- Jussim, Lee, Jacquelynn Eccles, and Stephanie Madon. "Social perception, social stereotypes, and teacher expectations: Accuracy and the quest for the powerful self-fulfilling prophecy." Advances in experimental social psychology 28 (1996): 281-388. <<http://www.sciencedirect.com/science/article/pii/S0065260108602403>>.
- Koenig, Barbara A., et al. "Genetic testing for BRCA1 and BRCA2: recommendations of the Stanford Program in Genomics, Ethics, and Society." Journal of Women's Health 7.5 (1998): 531-545. Web. 4 Dec. 2012. <[http://biochem118.stanford.edu/Papers/Ethical%20Issues/Choices-Biomedical\\_ethics.pdf](http://biochem118.stanford.edu/Papers/Ethical%20Issues/Choices-Biomedical_ethics.pdf)>.
- Lerman, Caryn, et al. "What you don't know can hurt you: adverse psychologic effects in members of BRCA1-linked and BRCA2-linked families who decline genetic testing." Journal of Clinical Oncology 16.5 (1998): 1650-1654. Web. 4 Dec. 2012. <<http://jco.ascopubs.org/content/16/5/1650.short>>.

- Loo, Sandra K., et al. "Genome-Wide Association Study of Intelligence: Additive Effects of Novel Brain Expressed Genes." *Journal of the American Academy of Child & Adolescent Psychiatry* (2012). Web. 4 Dec. 2012. <<http://www.ncbi.nlm.nih.gov/pubmed/22449649>>.
- Michie, Susan, Martin Bobrow, and Teresa M. Marteau. "Predictive genetic testing in children and adults: a study of emotional impact." *Journal of medical genetics* 38.8 (2001): 519-526. Web. 4 Dec. 2012. <<http://jmg.bmj.com/content/38/8/519.full>>.
- Palca, Joe. "Is Genome Sequencing Surpassing Medical Knowledge?" *Talk of the Nation*. NPR. 29 Oct. 2010. NPR.org. National Public Radio. Web. 4 Dec. 2012. <<http://www.npr.org/templates/story/story.php?storyId=130916257>>. Transcript.
- Perry, Samuel W., et al. "Psychological responses to serological testing for HIV." *AIDS; AIDS* (1990).
- Rosenthal, R. 2010. Pygmalion Effect. *Corsini Encyclopedia of Psychology*. 1–2.
- Rosenthal, Robert, and Lenore Jacobson. "Pygmalion in the classroom." *The Urban Review* 3.1 (1968): 16-20.
- Turkheimer, Eric. "Genome Wide Association Studies of Behavior are Social Science." *Philosophy of behavioral biology* (2012): 43-64. Web. 4 Dec. 2012 <<http://people.virginia.edu/~ent3c/papers2/Turkheimer%20GWAS%20EWAS%20Final.pdf>>.
- Willing, Richard. "Gene Tests Bring Agonizing Choices: Patients, Families, Doctors Wrestle with Privacy Issues." *USA Today*. USA Today, 23 Apr. 2001. Web. 4 Dec. 2012. <<http://usatoday30.usatoday.com/educate/college/sciart.htm>>.