Prepublication Copy of article accepted for publication in *High Ability Studies*

To Be or Not to Be (an Expert)?

Revisiting the Role of Deliberate Practice in

Improving Performance

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Abtract

In 2014, Macnamara, Hambrick, and Oswald published a meta-analysis of studies questioning the strength of the association between deliberate practice and performance1. In this brief report, the correlation reported by Macnamara et al. (2014) is placed in the context of other well-known associations. Additionally, a re-analysis of the studies included in Macnamara et al. (2014) was conducted. Taken together, the evidence suggests that deliberate practice is a potent and reliable method for improving performance.

To Be or Not to Be (an Expert)?

Revisiting the Role of Deliberate Practice in

Improving Domain-Specific Performance

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"My Lord, we know what we are now, but not what we may become."

Ophelia, Hamlet, Act 4, Scene 5

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Improving performance of any individual in any field—whether sports, music, chess, surgery, law, or psychotherapy—is a desirable goal, for the individual as well as for society. Psychology, no stranger to debates about nature versus nurture, has long discussed this topic, going back to Galton (1869) on the side of nature and Watson (1930) on the side of nurture (as discussed by Ullén, Hambrick, & Mosing, 2016). Recently, the debate over whether experts are born or made has been renewed, with a focus on the role of deliberate practice (DP). The term DP was first introduced by K. Anders Ericsson and colleagues, who defined it as:

> …Individualized training activities especially designed by a coach or teacher to improve specific aspects of an individual's performance through repetition and successive refinement. To receive maximal benefit from feedback, individuals have to monitor their training with full concentration, which is effortful and limits the duration of daily training. (Ericsson & Lehmann, 1996, pp. 278-279)

Shortly after the turn of the century, the concept of DP entered the popular culture. In his bestselling book *Outliers* the well-known writer Malcom Gladwell (2008) claimed "the magic number for true expertise [is] ten thousand hours" (p. 40). Other authors soon followed (c.f., Colvin, 2008; Syed, 2010), taking the argument a step further, boldly asserting, "Greatness isn't born. It's grown" (Coyle, 2009). It was a hopeful message, one that captured the public's imagination. Anyone, it seemed, could accomplish anything if they would just practice long enough. In the words of David Shenk (2010), author of *The Genius in All of Us: Why Everything You've been told about Genetics, Talent, and IQ is Wrong,* "Few of us know our true limits [and] the vast majority of us have not even come close to tapping…our 'unactualized potential'" (p. 9).

As appealing as these promises associated with DP were, both its role and the extent of its contribution to achieving expertise have been questioned (Anderson, 2016; Gardner, 1995; Marcus, 2012; Sternberg, 1996). In 2014, Macnamara et al. published a meta-analysis of studies examining the association between practice time and performance. After finding an overall aggregate correlation of .35 between DP and performance, the researchers concluded, "… deliberate practice is important, but not as important as has been argued" (p. 1).[2]

The competing explanation offered for individual differences in performance emphasizes the role of genetic factors, primarily intelligence (IQ) and genotypic physical characteristics (especially for sports and certain musical performance), as well as personality traits such as grit, and motivation (Ullén et al., 2016). The model that incorporates these factors, termed the Multifactorial Gene-Interaction Model (MGIM), focuses on "the potential importance of more complex interplay between genes and environment." The MGIM is thought to be necessary because "deliberate practice theory is unable to account for major recent findings relating to expertise and expert performance" (p. 427).

Of note, the Macnamara et al. (2014) meta-analysis, which questioned the strength of the association between DP and performance, generated nearly the same degree of public interest as

[2] The correlation of .35 originally reported in Macnamara et al. (2014) was subsequently corrected to .38 (Macnamara, Hambrick, and Oswald, 2018).

the prior work that emphasized DP. "New Study *Destroys* . . . [the] 10,000-hour Rule," *Business Insider* declared (Baer, 2014). Others agreed. "Scientists debunk the myth" that practice makes one an expert (Ferro, 2014). In *Slate* magazine, the banner for an article by Hambrick, Ferreira, and Henderson (2014) even claimed the whole idea of DP "perpetuates a cruel myth" as it promotes the false belief, "people can help themselves to the same degree if they just try hard enough."

At this time, the question of whether DP is the sole or primary contributor to the development of expertise is a matter of continuing debate (c.f., Ullén et al. 2016, Ericsson, 2014). No doubt, environmental factors and genetic predispositions are important (Miller and Hubble, 2011). Notwithstanding, of the many factors discussed in the expertise literature, DP represents one strategy performers can design and implement. In the end, the question that matters most is what any one person can do with what they are given (e.g., genetic makeup, time, money, access to teachers, etc.), to better their performance. As will be shown, regardless of recent depictions in popular media, DP is a key contributor to improvement in performance.

Correlations in Context

In their meta-analysis of 88 studies on practice and performance, McNamara et al. (2014) originally reported an aggregate correlation between practice and performance of .35, a figure later corrected to .38 (95% CI: .33; .42 [Macnamara, Hambrick, & Oswald, 2018]) – the revised value indicating that 14 percent of the variability in performance was explained by the amount of practice, leaving the remaining 86% percent unaccounted for by the variable. At first blush, such results might tempt one to discount the role of DP. And indeed, McNamara et al. (2014), and later, Ullén et al. (2016) did just that. Based on their interpretation that Ericsson and colleagues (1993) claim DP is the only (or predominant) factor leading to expertise, Ullén et al. criticized

DP for not accounting for "all, nearly all, or even most of the variance in expert performance, and often . . . only a surprisingly small proportion of the total variance" (p. 435).

Rather than debating whether Ericsson did or did not predict a correlation of a given size, or whether a correlation of .38 refutes DP theory, putting the correlation in the context of other well-known associations can be instructive. Consider several examples. First, few doubt whether obesity, excessive drinking, or smoking are unhealthy behaviors. Second, people with cardiac and metabolic diseases, as a rule, believe that adhering to their physicians' recommendations to take certain medications extends life. Third, people who are more intelligent are thought to be more successful and earn more than others. And finally, major league baseball players with the best batting averages are paid more than average players.

What are the *actual* correlations for these common, and presumably evidence-based beliefs? The correlations, as well as the proportions of variability in the criterion accounted for by each predictor, are presented in Table 1. Note however in this table a correlation of general mental abilities and job performance of around .50 (Schmidt & Hunter 2004), suggesting that abilities do have a role to play in performance.

Table 1

Correlation coefficients, and percent of variance accounted and unaccounted for between various predictor and criterion variables

Predictor Variable	Criterion Variable	Correlation Coefficient	Percent of Variance Accounted for by Predictor	Percent of Variance Unaccounted for by Predictor

Obesity[1]	Mortality	.08	<1%	>99%
Excessive Drinking[1]	Mortality	.13	1.5%	98.5%
Smoking[1]	Mortality	.21	4%	96%
Intelligence[2]	Income	.21	4%	96%
Adherence to Effective Medication[3]	Mortality	.23	5%	95%
Amount of Deliberate Practice	Performance	.38	14%	86%
Batting Average[4]	Major League Salary	.43	18%	72%
General Mental Ability[5]	Job Performance	.50	25%	75%

Note: Associations that were reported as odds ratios (OR) or ln(OR) were converted to approximate Pearson Product-Moment Correlations using methods described by Bonett (2007) and attributed to Pearson (1900).

[1]Holt-Lunstad et al. (2015) and/or Luo et al. (2012)

[2]Strenze (2007)

[3]Simpson et al. (2006)

[4]Averbukh, Brown, & Chase (2017)

[5]Schmidt & Hunter (2004)

Taking the values reported in Table 1 as benchmarks, the .38 correlation between practice and performance reported by Macnamara et al. (2014; 2018) is substantial. After all, the .08 to .23 correlations for the various predictors of mortality are large enough to justify the expenditure of massive amounts of time and money on public health policy and initiatives, aimed at changing people's behavior. In the United States, for instance, healthcare costs associated with obesity, the smallest correlation reported in Table 1, range from $147 to $210 billion dollars per year (Cawley & Meyerfoefer, 2009). An additional $60 billion is spent annually on weight lose products and programs (Williams, 2013).

Beyond whatever conclusions might be inferred from statistical correlations, for the true scientist, the issue of causality always remains. Any new student of statistics knows the maxim: correlation does not imply causation. And yet, in the real world, correlational data is often used to make actionable inferences. Ideally, experimental studies would be used to establish cause and effect (Holland, 1992, 1986; Rubin, 1986; Shadish, 2010). For all that, it must be remembered that the negative health effects of obesity, smoking, and excessive drinking have *never* been established experimentally—animal analogue studies aside, humans have never been randomly assigned to smoking and no smoking conditions, obese and non-obese conditions, or excessive drinking and non-excessive drinking conditions. For obvious reasons, causal attributions between various lifestyle behaviors and mortality must almost always be inferred (Kvaavik, Batty, Ursin, Huxley, & Gale, 2010; Mathers & Loncar, 2006; WHO, 2003). While, at present, there remains a scarcity of truly experimental studies of DP, the size of the correlation compared to other predictor variables is sufficient to recommend its application in performance improvement efforts.

Practice versus Deliberate Practice: Ambiguities in the Macnamara Meta-Analysis

Close examination of the studies comprising the Macnamara et al. (2014) meta-analysis yields even stronger support for the power of DP. In their investigation, studies were included if they contained: (1) a measure of accumulated amount (e.g., number of hours) of one or more activities interpretable as deliberate practice; (2) a reference to at least one publication on deliberate practice by Ericsson and his colleagues; (3) a measure of performance reflecting level of skill in the particular domain; (4) an effect size reflecting the relationship between accumulated amount of deliberate practice and performance; (5) results that were reported in English; and finally (6) participants who were human.

Unfortunately, although all 88 studies in Macnamara et al. (2014) were "interpreted" by the researchers as DP, in reality, they were not. Regardless of whether any one study met inclusion criteria number two (i.e., making reference to at least one citation of Ericsson), many were instances of mere time in spent in an activity that could be interpreted as related to the performance, but missing the essential components of *deliberate* practice. As just one example, one study (Ekstrand, 2007) included in Macnamara examined learning efficiency of university students enrolled in an introductory macroeconomics course. Study time and lectures attended comprised the deliberate practice variables but are two activities potentially unrelated to the performance measured (e.g., a student could sleep in class, for example, and it would still be counted as deliberate practice). Study time and lecture attended do not comprise aspects of deliberate practice. Not only were the key elements of DP absent, the impact of DP on performance was not the focus of the study. Rather, the intention was to investigate individual characteristics that influence study efficiency.

Macnamara Redux

To examine the influence of ambiguities in the results reported by Macnamara et al. (2014), a reanalysis of the original dataset was conducted. We should note that there has been a great deal of inconsistency in the definition of DP (b) Macnamara et al. used a very broad definition of DP, (c) a narrower definition of DP that more closely aligns with the principles of DP could have been used, and (d) our reanalysis reports results when a narrower definition is used.

Raters coded each study as to whether it qualified as an instance of deliberate practice. They were blind to both the identity of the authors and the research results, making their determinations using only the methods section of each report. In short, a study was coded as DP if and only if it explicitly indicated it estimated the effects of *deliberate practice,* and the dependent variable was a measure of performance *specific* to the domain targeted by the practice.

Out of the 88 studies included in Macnamara et al. (2014) meta-analysis, 18 failed to meet the criteria for DP. These 18 yielded a total of 45 effect sizes, which were, in fact, reports of activity hours, not DP. Of interest, the 18 studies all came from the domain of education (see, Supplementary Material) representing a board range of subject areas (e.g., business, organic chemistry, psychology, mathematics, etc). In all instances, the studies were not designed to investigate the effects of deliberate practice on performance.

Using the effects and standard errors (adjusted) reported by Macnamara et al. (2014), the aggregate correlation between practice and performance was calculated for studies classified as DP research, and those identified as activity hours, using standard methods for aggregating correlations (Shadish & Haddock, 2009; computed using the R statistical software package for meta-analysis 'MAc' [Del Re & Hoyt, 2010]). The results of this reanalysis are found in Table 2.

Table 2 A Comparison of Effects of Practice versus Deliberate Practice

Number of effects	Aggregate Correlation	Standard Error Wo	p	CI
Effects of Deliberate Practice				
102	.40	.0281	<.0001	.34; 46
Effects of Activity Hours (not deliberate practice)				
45	.21	.0271	<.0001	.16; 26

The results indicate that the correlation coefficient for deliberate practice effects (viz., .40) was significantly larger than non-deliberate practice studies (viz., .21, $p < .001$). Reference to Table 1 further shows the aggregate correlation for DP studies is in the range of the largest correlation presented (batting average and salaries of major league baseball players).

To Be or Not to Be (An Expert): What *is* the Question?

When it comes to accounting for any aspect of human behavior, the pendulum of popular opinion often swings from one extreme to the other. Are experts born or made? The answer is, "yes and yes." As Ullén et al. (2016) argue persuasively, genetic makeup matters, as does the environment into which one is born and lives. Aside from these "givens," *the* question remains: What can a person actually do to improve their performance?

In contrast to how the results of Macnamara et al. (2014) have been portrayed in the press (Allison, 2016; Konnikova, 2016; Strauss, 2014), this meta-analysis found what turns out to be a relatively large correlation between DP and improved performance compared to other associations considered critical (e.g., the correlations of smoking, obesity, and excessive drinking with mortality). More, as has been shown in the present report, the magnitude of the relationship is even greater when studies are limited in the analysis to bona fide instances of DP.

The discussion about the importance of deliberate practice raises an important methodological and conceptual issue. The question of whether natural talent is associated with performance is a between-person effect: Those persons with more natural ability than others will perform better. On the other hand, DP is a within-person effect: As individuals practice more, they will perform better. Research designs and statistical methods for disaggregating between-person and within-person effects have been discussed (Curran & Bauer, 2011; Wang & Maxwell,

2015) and could profitably be used to study the effects of trait like variables (e.g., ability) and state like variables (DP or environment) on performance.

Improving performance is a worthy goal. As has been shown, there is sufficient evidence, even from critics, that DP is associated with performance. Understanding the complex role "nature" can play may serve as a buffer to unlimited aspiration and potential disappointment. At the same time, such understanding is only likely when: (1) research included in any analysis is an actual study of DP; and (2) the criteria for what constitutes DP are standardized, made explicit, accepted by researchers, and applied consistently across studies. To that end, we propose that in future studies, any activity deemed DP meet the following four criteria: (1) individualized learning objectives; (2) ongoing feedback regarding performance and learning; (3) involvement of a coach; and (4) successive refinement through repetition most often conducted alone (Ericsson & Lehmann, 1996). To this point, it is noteworthy that even work published by Ericsson, the researcher credited with originating the term, do not meet these four criteria and often change from one study or publication to another (c.f., Duffy, Baluch, & Ericsson, 2004; Ericsson et al., 1993; Ericsson, 2007; Plant, Ericsson, Hill, & Asberg, 2005; Tuffiash, Roring, & Ericsson, 2007).

Despite such considerations, available evidence indicates engaging in DP is a reliable method improving performance. As the celebrated UCLA basketball coach John Wooden once observed, "Do not let what you cannot do interfere with what you can do."

ENDNOTES

1. Thanks to Macnamara and colleagues for making their data available for the present analysis.

References

Allison, K. (2016). There's more than practice to becoming a world-class expert. *The Conversation*. http://theconversation.com/theres-more-than-practice-to-becoming-a-world-class-expert-60430. Retrieved May 2nd, 2017.

Anderson, T., McClintock, A. S., Himawan, L., Song, X., & Patterson, C. L. (2016). A prospective study of therapist facilitative interpersonal skills as a predictor of treatment outcome. *Journal of Consulting and Clinical Psychology, 84*(1), 57-66. doi:http://dx.doi.org/10.1037/ccp0000060.

Averbukh, M., Brown, S., & Chase, B. Baseball pay and performance. Retrieved from https://ai.arizona.edu/sites/ai/files/MIS580/baseball.pdf, April 25, 2017.

Baer, D. (2014). New study destroys Malcom Gladwell's 10,000 hour rule. *Business Insider.* http://www.businessinsider.com/new-study-destroys-malcolm-gladwells-10000-rule-2014-7. Retrieved May 2nd, 2017.

Bonett, D. G. (2007). Transforming odds ratios into correlations for meta-analytic research. *American Psychologist, 62*(3), 254-255. doi:http://dx.doi.org/10.1037/0003-066X.62.3.254.

Cawley J, & Meyerhoefer C. (2013) The medical care costs of obesity: An instrumental variables approach. *Journal of Health Economics*, *31*(1): 219-230.

Colvin, G. (2008). *Talent is overrated: What really separates world-class performers from everybody else*. Clerkenwell, London: Nicholas Brealey Publishing.

Coyle, D. (2009). *The talent code: Greatness isn't born. It's grown. Here's how.* New York, New York: Bantam.

Curran, P. J., & Bauer, D. J. (2011). The disaggregation of within-person and between person effects in longitudinal models of change. Annual Review of Psychology, 62, 5833-5619. doi:10.1146/annurev.psych.093008.100356

Del Re, A. C., & Hoyt, W. T. (2010). MAd: meta-analysis with mean differences. *R package version 0.9 ed*.

Duffy, L., Baluch, B., & Anders Ericsson, K. (2004). Dart performance as a function of facets of practice amongst professional and amateur men and women players. *35*, 232-245.

Ekstrand, J, (2007) Measuring and explaining economic students learning efficiency. Paper presented at the 25th Arne Ryde Symposium, Lund University, Sweden.

Ericsson, K.A. (2014). Expertise. *Current Biology, 24*, R508-R510. doi: http://dx.doi.org/10.1016/j.cub.2014.04.013

Ericsson, K., Roring, R. W., & Nandagopal, K. (2007). Misunderstandings, agreements, and disagreements: Toward a cumulative science of reproducibly superior aspects of giftedness. *High Ability Studies, 18*(1), 97-115. doi: http://dx.doi.org/10.1080 /13598130701351088

Ericsson, K. A., Krampe, R. T., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*(3), 363-406.

Ericsson, K. A., & Lehmann, A. C. (1996). Expert and exceptional performance: Evidence of maximal adaptation to task constraints. *Annual Review of Psychology, 47*(1), 273-305. doi:10.1146/annurev.psych.47.1.273.

Ferro, S. (2014). Scientists debunk the myth that 10,000 hours of practice makes you an expert. *Co.Design*. https://www.fastcodesign.com/3027564/scientists-debunk-the-myth-that-10000-hours-of-practice-makes-you-an-expert. Retrieved May 2nd, 2017.

Galton, F. (1869). *Hereditary genius*. London, England: Macmillan.

Gardner, H. (1995). "Expert performance: its structure and acquisition": A comment. *American Psychologist, 50,* 802-803. doi:10.1037/0003-066X.50.9.802.

Gladwell, M. (2008). *Outliers: The story of success*. Park Avenue, New York: Little, Brown and Company.

Hambrick, D.Z., Ferreira, F., & Henderson, J.M. (2014). Practice does not make perfect: We are not all created equal where our genes and abilities are concerned. *Slate*. http://www.slate.com/articles/health_and_science/science/2014/09/malcolm_gladwell_s_10_000_hour_rule_for_deliberate_practice_is_wrong_genes.html. Retrieved May 2nd, 2017.

Holland, P. W. (1986). Statistics and causal inference. *Journal of the American Statistical Association, 81*(396), 945-960. doi:10.2307/2289064

Holland, P. W. (1992). Which comes first, cause or effect? In G. Keren, C. Lewis, & (Eds.). *A handbook for data analysis in the behavioral sciences: Methodological issues.* (pp. 273-282). Hillsdale, NJ England: Lawrence Erlbaum Associates, Inc.

Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D. (2015). Loneliness and social isolation as risk factors for mortality: A meta-analytic review. *Perspectives on Psychological Science, 10*(2), 227-237. doi:10.1177/1745691614568352.

Konnikova, M. (2016). Practice doesn't make perfect. *The New Yorker*. http://www.newyorker.com/science/maria-konnikova/practice-doesnt-make-perfect. Retrieved May 2nd, 2017.

Kvaavik, E., Batty, G.,Ursin, G., Huxley, R., Gale, C. (2010). Influence of individual and combined health behaviors on total and cause-specific mortality in men and women: The

United Kingdom health and lifestyle survey. *Archives of Internal Medicine, 170*(8): 711-718.

Luo, Y., Hawkley, L. C., Waite, L. J., & Cacioppo, J. T. (2012). Loneliness, health, and mortality in old age: A national longitudinal study. *Social Science & Medicine, 74*(6), 907-914. doi:http://dx.doi.org/10.1016/j.socscimed.2011.11.028

Marcus, G. (2012). *Guitar hero*: *The science of becoming musical at any age*. New York, New York: Penguin.

Macnamara, B. N., Hambrick, D. Z., & Oswald, F. L. (2014). Deliberate practice and performance in music, games, sports, education, and professions: A meta-analysis. *Psychological Science, 25*(8), 1608-1618. doi:http://dx.doi.org/10.1177/0956797614535810.

Macnamara, B. N., Hambrick, D. Z., & Oswald, F. L. (2018). Corrigendum: Deliberate practice and performance in music, games, sports, education, and professions: A meta-analysis. Psychological Science, 29(7), 1202-1204. doi:http://dx.doi.org/10.1177/0956797618769891

Mathers, C.D., & Loncar, D. (2006). Projections of global mortality and burden of disease from 2002 to 2030. *PLOS: Medicine.* https://doi.org/10.1371/journal.pmed.0030442.

Miller, S. D., & Hubble, M. (2011). The road to mastery. *Psychotherapy Networker, 35,* 22-31, 60.

Pearson, K. (1900). Mathematical contributions to the theory of evolution—VII: On the correlation of characteristics not quantitatively measurable. *Philosophical Transactions of the Royal Society of London, Series A, 195,* 1–147.

Plant, A., Ericsson, A. K., Hill, L., & Asberg, K. (2005). Why study time does not predict grade point average across college students: Implications of deliberate practice for academic performance. *30*, 96-116. doi:10.1016/j.cedpsych.2004.06.001

Rubin, D. B. (1986). Statistics and causal inference - which ifs have causal answers. *Journal of the American Statistical Association, 81*(396), 961-962. doi:10.2307/2289065

Schmidt, F. L., & Hunter, J. (2004). General Mental Ability in the World of Work: Occupational Attainment and Job Performance. *Journal of Personality and Social Psychology*, 86(1), 162-173. doi:http://dx.doi.org/10.1037/0022-3514.86.1.162

Shadish, W. R. (2010). Campbell and Rubin: A primer and comparison of their approaches to causal inference in field settings. *Psychological Methods, 15*(1), 3-17. doi:10.1037/a0015916

Shadish, W. R., & Haddock, C. K. (2009). Combining estimates of effect size. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta-analysis (2nd ed.).* (pp. 257-277). New York, NY US: Russell Sage Foundation.

Shenk, D. (2010). *The Genius in all of us: Why everything you've been told about genetics, talent, and IQ is wrong*. New York: Random House.

Simpson, S. H., Eurich, D. T., Majumdar, S. R., Padwal, R. S., Tsuyuki, S. T., Varney, J., & Johnson, J. A. (2006). A meta-analysis of the association between adherence to drug therapy and mortality. *British Medical Journal, doi:10.1136/bmj.38875.675486.55*

Sternberg, R.J. (1996). The costs of expertise. In K.A. Ericsson (Ed.). *The road to excellence: the acquisition of expert performance in the arts and sciences, sports, and games* (pp. 347-354). Mahwah, New Jersey: Erlbaum.

Strauss, V. (2014). Actually, practice doesn't always make perfect—new study. *The Washington Post*. https://www.washingtonpost.com/news/answer-sheet/wp/2014/07/25/actually-practice-doesnt-always-make-perfect-new-study/?utm_term=.a2676a44ca00. Retrieved May 2nd, 2017.

Strenze, T. (2007). Intelligence and socioeconomic success: A meta-analytic review of longitudinal research. *Intelligence, 35*(5), 401-426. doi:http://dx.doi.org/10.1016/j.intell.2006.09.004

Syed, M. (2010). *Bounce: Mozart, Federer, Picasso, Beckham, and the science of success*. Great Britain: Harper Collins Publisher.

Tuffiash, M., Roring, R. W., & Ericsson, K. (2007). Expert performance in SCRABBLE: Implications for the study of the structure and acquisition of complex skills. *Journal of Experimental Psychology: Applied, 13*(3), 124-134.

Ullén, F., Hambrick, D. Z., & Mosing, M. A. (2016). Rethinking expertise: A multifactorial gene-environment interaction model of expert performance. *Psychological Bulletin, 142*(4), 427-446.

Wang, L., & Maxwell, S. E. (2015). On disaggregating between-person and within-person effects with longitudinal data using multilevel models. *Psychological Methods*, 20(1), 63-83. doi:http://dx.doi.org/10.1037/met0000030

Watson, J. B. (1930). Behaviorism. Chicago, IL: The University of Chicago Press.

Williams, G. (2013) The heavy price of losing weight. *U.S. News & World Report.* http://money.usnews.com/money/personal-finance/articles/2013/01/02/the-heavy-price-of-losing-weight. Retrieved May 2nd, 2017.

WHO (2003). Neglected global epidemics: Three growing threats (pp.85-102). *The World Health Report*. http://www.who.int/whr/2003/en/Chapter6-en.pdf. Retrieved May 2nd, 2017.