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Polymathy Among Nobel Laureates As a Creative Strategy— The Qualitative and Phenomenological Evidence

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ABSTRACT

Previous statistical studies found that polymathic networks of vocational and avocational interest predominate among Nobel Prize winners, discriminating them from less-successful peers. Here we confirm qualitatively and phenomenologically that this multidisciplinary is a considered creative strategy. Peers often recognize Nobel laureates as “Renaissance” intellectuals; Nobel Prize committees often award their prizes for transdisciplinarity and integration; Nobel laureates often describe their polymathy as conscious choice to optimize creative potential. That so many Nobel laureates should develop diverse interests and harness them to creative ends is, probably, the result of a confluence of factors. Laureates experience, on average, enhanced access to education; they train differently and more broadly than their peers; they retrain and extend themselves as serious amateurs; and they meld vocational and avocational sets of skills and knowledge into integrated networks of transdisciplinary enterprise. In effect, this combinatorial approach to learning and doing enables them to perceive unusual problems at the intersections of disciplines, to transfer ideas and techniques from one field to another, and/or to synthesize knowledge across domains. Specializing in breadth can be a path to innovation comparable to, and (at least in terms of Nobel Prizes) arguably better than, specialization alone.

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The growth of alternative mental interests is a long process. The seeds must be carefully chosen; they must fall on good ground; they must be sedulously tended, if the vivifying fruits are to be at hand when needed.

~ Winston Churchill, Nobel Prize in Literature, 1953

(*Painting as Pastime*, 1950, 8)

Introduction

The life stages of creativity are diverse (Root-Bernstein & Root-Bernstein, 2011), but one pattern of individual behavior appears to show “continuous effective creativity”: that of the polymath or multidisciplinary, where both terms refer to active engagement in multiple diverse interests, vocational or avocational (Root-Bernstein & Root-Bernstein, 2011, 52; Rehman, 2015, n.p.). Whether serially or simultaneously, within or across fields, in mixed vocational or mixed vocational-avocational activity, the polymath commits to more than one disciplinary field or domain of knowledge over the course of a lifetime.

In a recent study of interest patterns among Nobel laureates awarded prizes in the sciences, in economics and literature, and for peace, Root-Bernstein and Root-

Bernstein (2020b) reported high rates of trans-domain polymathy, tracked as enduring interest in two or more of seven activity areas: crafts, performance arts, artistic writing, humanities and social sciences, sciences, nature activities, and sports. Nobel Prize winners in physics and physiology or medicine with two or more domain interests outnumbered those with one domain interest two to one while among economics laureates, those with two or more different domain interests outnumbered those with one by nineteen to one, while chemistry, peace and literature laureates fell between these extremes (Root-Bernstein & Root-Bernstein, 2020b, 106). Similarly, Nobel Prize winners demonstrate intra-domain polymathy by combining two or more developed interests within their professional domains (the social sciences/humanities, literature, economics, or the sciences) at rates ranging between 54% for peace laureates to 84% of physiology or medicine laureates with the other laureates spread between. More than half of Nobel laureates have engaged in *both* trans- (across) domain and intra- (within) domain polymathy (Root-Bernstein & Root-Bernstein, 2020b, Tables 11, 12, 13). These rates of trans-domain, intra-domain, and combined domain polymathy very significantly distinguish Nobel laureates from typical professionals in these fields and members of

the general public, strongly suggesting that such polymathic tendencies may account for at least some part of their creative ability.

Statistics reveal useful abstractions about complex systems such as polymathy, but the resulting correlations remain in need of causal explanations and tests that anecdotal and other qualitative data can provide. We summarize here three types of qualitative and phenomenological evidence relevant to testing possible explanations of the correlation between polymathic behaviors and attainment of the highest levels of creative output as measured by Nobel Prizes. First, peers and other commentators often describe laureates as polymaths or “Renaissance” men and women, often before receipt of the Nobel Prize, suggesting that their polymathic thinking and behaviors are sufficiently atypical to be linked by peers to creative brilliance. Second, Nobel award committees often cite evidence of multiple interests and their integration as key criteria for winning the Nobel Prize. Third, and perhaps most importantly, Nobel laureates themselves often make explicit the substantive and useful connections between their multiple interests, recognizing, in essence, the integrated networks of multidisciplinary activity that stimulate and sustain their creative work. Taken together, these three types of evidence suggest that the statistical correlations between polymathic behavior and Nobel Prizes may result from conscious strategic decisions that Nobel laureates make about how to train themselves, what kinds of problems they choose to tackle, and the ways in which these choices are perceived and evaluated by others.

Methods

Evidence of multidisciplinary activity was gathered for all 773 individual Nobel laureates in physiology or medicine, chemistry, physics, literature, economics, and peace who received the award from the prize’s inception in 1901 to 2008. The autobiographical and biographical statements by and for laureates at the Nobel Prize Foundation website (NobelPrize.org), as well as all linked resources listed on the site, were mined for references to polymathic characteristics, behaviors, and rationales. We used other general sources for each group of laureates: For science laureates, *Biographical Memoirs of the Royal Society* (Royal Society Publishing.org) and *National Academy of Sciences (USA) Biographical Memoirs* (Nasonline.org.); for literature laureates, Pribic (1990) and Liukkonen and Pesonan (1997-2020); for economics laureates, Hirsch and Breit (2009) and Wahid (2002); for peace laureates, Abrams (2012). We consulted Wikipedia for additional information of

traceable provenance. Finally, book-length biographies and autobiographies supplemented these shorter sources for about ten percent of the laureates in all categories. Additional sources for individual laureates have been noted at appropriate points in the text below and, in a few instances, examples from Nobel laureates who won their awards after 2008 have also been cited.

Evidence concerning vocational and avocational pursuits, or their explicit absence, was located for approximately 80% of the scientists, 93% of literature laureates, 95% of economics laureates, and 92% of peace laureates (Root-Bernstein & Root-Bernstein, 2020b). No evidence regarding avocational pursuits was found for the remaining individuals. Extended commentary on multidisciplinary activity or its absence, available in a subset of cases, was catalogued and collated in search of patterns of behavior. The examples provided below are a selection of the available qualitative and phenomenological data.

Results

Polymathic activity and its recognition by others

Nobel laureates in literature, in economics, in the sciences, and in peace have often drawn attention from colleagues as unusual individuals with polymathic or “Renaissance” ranges of interests and abilities. Four exemplary profiles give a flavor of how these laureates often combined simultaneous or serial combinations of vocation and avocation.

The Bengali poet and composer Rabindranath Tagore, the first non-European to win the Nobel Prize for Literature [1913], impressed the West with achievements both within and across domains. Within his prize-winning domain there was hardly a genre he did not attempt, including, in addition to poetry for which he won the Nobel, plays, essays, short stories, and novels – not to mention the lyrics for thousands of songs of his own musical composition. Much of this art contributed philosophically and practically to the politics of colonial emancipation in India. In 1901 he established an experimental school at Santiniketan (now Visva-Bharati University) dedicated to his radical notions of learning outdoors and through the arts (“Tagore’s Santiniketan,” 2021). Later in life Tagore turned to painting, with his first European show at the age of 69 and a posthumous international exhibition as recently as 2011 (“The last harvest,” 2021). All told, Tagore excelled “in at least five overlapping worlds” – religious, educational, philosophical, political, as well as literary and artistic (Dutta & Robinson, 1995, 78, 289).

In a similar vein, the economist Kenneth Arrow impressed his colleagues with a breadth of knowledge that roamed far from his social science specialty into the arts and humanities. In 1972 he won the Nobel Prize (jointly with John Hicks) for fundamental and diverse contributions to economics, including essential conceptual tools that pioneered the new field of social choice theory. He had substantial impact as well on health economics and environmental economics and was prodigiously interested in “a myriad of other subjects,” including arts, literature, music, and the biological sciences. On one occasion, he “held his own at a dinner party with a scholar of Chinese art” (“An impossible mind,” 2017); on another, he knew more about the breeding habits of gray whales than the junior faculty who sought, good-naturedly, to trip him up (Weinstein, 2017). Widely known as a brilliant economic mind, he said of himself that he was “a systematizer by talent and inclination” (cited in Szenberg, 1992, 44) – one as apt to look for patterns in art, music, and the natural world as in economic behaviors (McCarty, 2001, 40).

Fridtjof Nansen, peace laureate of 1922, was strongly advised in youth to focus on no more than one of his “too many talents” (Høyer, 1957, 13); he chose instead a pattern of broad vocational and avocational activity that launched him as a “pioneer and innovator in many fields” (“Fridtjof Nansen,” 2021). An avid outdoor sportsman and early adopter of new skiing methods, Nansen won a national cross-country skiing race in Norway twelve years in a row (Abrams, 2012, 102). Simultaneously, he earned a Ph.D. in zoology, contributing to the new science of neurology (Whiteley, 2006, 1653; Haas, 2003, 515) before turning his attention to oceanography and polar sciences, where his skiing prowess was an essential skill (Gjelsvik, 1994, 1). He also pursued interests in drawing, painting, and photography (Høyer, 1957, 256). By his late twenties, Nansen had seamlessly integrated these diverse interests as an intrepid and inventive explorer, roaming the far reaches of Greenland and then the Arctic Circle. For his explorations, he specially designed a ship to sustain ice-bound drift to the North Pole, invented and improved expedition equipment, collected voluminous data on the polar sea, and self-illustrated academic and popular publications that established his fame worldwide (Høyer, 114, 256; Abrams, 2012, 102). On the strength of this renown, and his international travels, Norway tapped Nansen for critical diplomatic posts, where again he set precedents, introducing “Nansen passports” for the stateless to ease resettlement of half a million POW’s and hundreds of thousands of refugees in the aftermath of World War I (Abrams, 2012, 103; NobelPrize.org, 1922).

Chemist Dorothy Crowfoot Hodgkin exhibited a similarly varied set of experiences. Home schooled by her archeologist-botanist parents at their dig sites, she was taught to record everything she learned both in words and in drawings or paintings. By age eighteen, she was illustrating her parents’ professional publications and considered becoming a professional archeologist herself. Chemistry, however, captured her imagination. Her highly trained visual ability became one of her great strengths when she began studying the new science of x-ray crystallography, a field in which she pioneered applications to biological molecules such as penicillin, vitamin D, and insulin. This work helped to establish the new science of molecular biology. Not only did she decipher protein structures; sometimes, as with insulin, she painted them, too (R. Root-Bernstein, 2007), and consulted with the organizers of the 1951 Festival of Britain to have these patterns transformed into wall-papers, fabrics, and fine china designs (Jackson, 2008). She was also politically active. In 1976, she began her term as the longest-serving president of the Pugwash Conferences on Science and World Affairs, an international collaborative of scientists dedicated to reducing the risk of armed conflict throughout the world (Ferry, 1998).

Tagore, Arrow, Nansen, and Crowfoot Hodgkin are unusually accomplished individuals and yet they are anything but unusual among Noble Prize winners. Over the last hundred and twenty years, numerous other laureates have been noticed for similarly broad interests. Indeed, colleagues and peers often used labels such as “polymath,” its synonym “polyhistor,” the more widely understood “Renaissance man [sic]” or other, similar appellations for many a Nobel laureate. For his combined achievements in sports, exploration, science, and pioneering diplomacy, Nansen has been called an “archetype of the creative individual” (Larsson, 2006, 105). Among peace laureates, one might add to his example the Belgian international lawyer Henri Marie La Fontaine [Nobel Prize (hereinafter NP) 1913], who impressed contemporaries as a “many-sided man” of great talent – not only for his vocational expertise in law and politics, but for his avocational piano recitals, libretto translations, and knowledge of the fine arts (Abrams, 2012, 82–83). Dag Hammarskjöld [NP 1961], “often described as a twentieth century Renaissance man,” (Dag Hammarskjöld Foundation, 1987) had degrees in philosophy, law, and economics and was, in addition to being the diplomat who transformed the United Nations into an effective international organization, also an accomplished mountain climber, haiku poet, philosopher, and photographer. Jason Shogren, an environmental economist and 2007 Nobel Peace

Prize winner, has also won the sobriquet of “Renaissance” person for pursuing his second profession as a musician and composer with five blues CDs to his credit (Storrow, 2013).

Among literature laureates, Bertrand Russell [NP 1950] – logician, mathematician, historian, writer, and philosopher – is often referred to as a polymath (Bertrand Russell, 2021). The Mexican poet, intellectual, and diplomat Octavio Paz [NP 1990] has also been called “a genuine polymath, a rediscoverer” and a “Renaissance man” for his combination of surrealist poetry and wide-ranging essays on poetics, literary and art criticism, history, and politics (Stavans, 2001, 3–4). Winston Churchill [NP 1953] has been compared to the multi-faceted Leonardo da Vinci for his contributions to history, literature, and politics (Taylor, 1954, 5). Elias Canetti [NP 1981] has been called a “polyhistor” for his ability to integrate history, culture, sociology, and psychology in his literature (NobelPrize.org, 1981a); Guenter Grass, [NP 1999], a “Renaissance man” for working simultaneously as a graphic artist, poet, playwright, and novelist (Fisher & Weeks, 1999); as have Derek Walcott [NP 1992], for his combination of poetry, playwriting and painting (McCallister, 2017) and Dario Fo [NP 1997], for his accomplishments as director, actor, set and costume designer, songwriter, choreographer, painter, scholar, and political activist (Cowan, 1979; NobelPrize.org, 1997a).

Nobel Prize-winning scientists display similarly polymathic accomplishments and some, such as Ronald Ross [Physiology or Medicine (hereinafter Med) 1902], have often been labelled as “Renaissance” intellectuals (Megroz, 1931; R. Root-Bernstein, 2010). Ross is best known today for discovering the cause of malaria, which earned him his Nobel Prize; to explain the epidemiological spread of malaria, he also invented the statistical concept of the random walk, an innovation of great importance to statistics and to epidemiology (Ellenberg, 2021). He was also known to contemporaries as a notable poet, novelist, musician, composer, and painter.

Among many other science laureates deemed “Renaissance” persons, one might mention Enrico Fermi [Physics 1938] whose biography is entitled “The Last Man Who Knew Everything,” (Schwartz, 2017), Hugo Theorell [Med 1955] (Theorell, 1955), Max Delbruck [Chemistry 1962] (Rhodes, 2003), Murray Gell-Mann [Physics 1969] (Santa Fe Institute, 2019), Gerald Edelman [Med 1972] (Seth, 2014), Ilya Prigogine [Physics 1977] (“Profiles,” 1977), Philip Anderson [Physics 1977] (Princeton University, 2020); Roald Hoffman [Chemistry 1981] (Hunter College, 2021), Pierre-Gilles de Gennes [Physics 1991] (Augereau & le Hir, 2007), George Olah [Chemistry

1994] (Prakash, 2017), and Eric Kandel [Med 2000] (Washington University, 2014). Each of these laureates roamed over multiple scientific and non-scientific fields.

Nobel Prize-winning economists often share this polymathic label, typically combining mathematical or scientific with humanistic training as part of their formal education (Root-Bernstein & Root-Bernstein, 2020). Among economics laureates, Arrow was considered “famously, a polymath, steeped in philosophy and literature” (“An impossible mind,” 2017), as well as “an Albert Einstein of economics” (Shashkevich, 2017, n.p.). “If any twentieth-century economist was a Renaissance man [sic],” it was Friedrich Hayek [NP 1974], for his “fundamental contributions in political theory, psychology, and economics” (“Friedrich August Hayek,” n.d.). Herbert Simon [NP 1978] also earned notice as “the one man in the world who comes closest to the idea of [. . .] a Renaissance man” (Wahid, 2002, 135; Larsson, 2006, 157). His academic contributions encompassed computer science, artificial intelligence, psychology, philosophy, and economics (Williamson, 2004, 280).

In sum, dedication to multi-faceted disciplinary and avocational engagement and contribution runs through the life work of many Nobel laureates in all categories to such an extent that peers and colleagues noted, understood, and appreciated this. Notably, the same appreciation of multidisciplinary may be found as an unstated criterion for selection by Nobel Prize committees, too. To this we turn next.

Multidisciplinary as an unstated criterion in nobel citations

According to Alfred Nobel’s will, the Nobel Prizes are “to be distributed annually” to individuals who in their work “have conferred the greatest benefit to humankind” within certain specified fields of knowledge and action:

The interest is to be divided into five equal parts and distributed as follows: one part to the person who made the most important discovery or invention in the field of physics; one part to the person who made the most important chemical discovery or improvement; one part to the person who made the most important discovery within the domain of physiology or medicine; one part to the person who, in the field of literature, produced the most outstanding work in an idealistic direction; and one part to the person who has done the most or best to advance fellowship among nations, the abolition or reduction of standing armies, and the establishment and promotion of peace congresses. (“Alfred Nobel’s will,” n.d.)

The prize in economics, established some seventy-five years later by the Sveriges Riksbank (the Central Bank of Sweden), is awarded “according to the same principles as for the Nobel Prizes” (“About the Prize,” n.d.) Since physics, chemistry, physiology or medicine, literature, peace, and economics are each well-defined disciplines, it comes as a surprise to find that awards committees very often select individuals for multidisciplinary efforts.

Perusal of award ceremony presentation speeches, press releases, biographical facts, and “Prize motivations” archived on the Nobel Prize website suggest that Nobel Prize committees have in fact been highly sensitive in their award determinations to the integration and combination of previously disparate fields. In other words, productive polymathy has served Nobel committees as one recognizable marker for award-worthy creative achievement.

At least a quarter of Nobel laureates in literature (through 2008) received their awards for work in more than one genre. By way of example, prize “motivations” explicitly cite Frédéric Mistral for “the fresh originality . . . of his poetic production” and also “his significant work as a Provençal philologist” (NobelPrize.org, 1904); Paul Johann Ludwig Heyse for “his long productive career as a lyric poet, dramatist, novelist and writer of world-renowned stories” (NobelPrize.org, 1910); Maurice Maeterlinck for “his many-sided literary activities” (NobelPrize.org, 1911b); Pearl Buck for “epic descriptions of peasant life in China and for her biographical masterpieces” (NobelPrize.org, 1938); Winston Churchill for “his mastery of historical and biographical description as well as for brilliant oratory” (NobelPrize.org, 1953); Boris Pasternak for “important achievement both in contemporary lyrical poetry and in the field of the great Russian epic tradition” (NobelPrize.org, 1958); Samuel Beckett for “new forms for the novel and drama” (NobelPrize.org, 1969); and Elfriede Jelinek for the “musical flow of voices and counter-voices in novels and plays” (Nobelprize.org, 2004a). Such prizes recognize explicitly the phenomenon that Root-Bernstein and Root-Bernstein (2020a) documented statistically, which is that Nobel laureates in literature have been very likely to integrate many artistic genres.

Yet another set of “motivations” and commendations focus on the literature laureate’s breadth of vision, often involving the integration of diverse materials, forms, and traditions. Sully Prudhomme, who won the first literature award in 1901, “combined a Parnassian regard for formal perfection and elegance with philosophic and scientific interests” (Nobel Prize.org, 1901). Similarly, Johannes V. Jensen was recognized “for the rare strength and fertility of his poetic imagination with which is combined an intellectual curiosity of wide scope and

a bold, freshly creative style [in his novels]” (NobelPrize.org., 1944a); Elias Canetti for “writings marked by a broad outlook, a wealth of ideas and artistic power” (NobelPrize.org, 1981b); Gabriel García Márquez “for his novels and short stories, in which the fantastic and the realistic are combined in a richly composed world of imagination” (NobelPrize.org, 1982); Claude Simon for combining in his novels “the poet’s and the painter’s creativeness with a deepened awareness of time in the depiction of the human condition” (NobelPrize.org, 1985a); Wole Soyinka for the “wide cultural perspective” with which he “fashions the drama of existence” and the synthesis of cultures (NobelPrize.org, 1986); and Octavio Paz for “impassioned writing with wide horizons . . . ” (NobelPrize.org, 1990). Writing for the Nobel Prize Organization, Georgia Brown (2007) reiterated the institution’s attention to integrative accomplishment when she noted that 2007 laureate Doris Lessing “mixed high literature with more popular forms, like science fiction, and has daringly employed strange combinations of time-schemes, perspective, allegory, and naturalism in an attempt to access what she sees as the deeper reality of mysticism, dreams and even madness” (n.p.).

Prize “motivations” in economics have also tended to focus on pioneering connections between economic specialties or between economics and other fields usually considered quite distinct. The Nobel Prize organization itself made note of this trend in a review of the prizes from 1969–2007, listing many of the awards under the heading “Interdisciplinary Research” (Lindbeck, 2020, n. p.). Laureates named in this category include James Buchanan [NP 1986], “for his research on the boundary between economics and political science;” Gary Becker [NP 1992], for work “on the borderline between economics and sociology;” Ronald Coase [NP 1991], for “important contributions on the borderline between economics, law and organization;” Herbert Simon [NP 1978], who “on the basis of both empirical evidence and psychological theory . . . [became] a main contributor in the field administrative (management) science;” and Simon Kuznets [NP 1971], for “empirical research on the borderline between economics and history” (Lindbeck, 2020, n.p.).

Additionally, the economics prize went to Robert Fogel and Douglass North in 1993 as yet another award for research “on the boundary between economics and history” and to Amartya Sen in 1998 for research on the borderline between economics and philosophy (Lindbeck, 2020, n.p.). Sen has in fact been credited with integrating “three distinct but interrelated disciplines . . . : welfare economics, social choice, and development economics” (Wahid, 2002, 377). The award to

Friedrich Hayek and Gunnar Myrdal in 1974 also had a strong interdisciplinary flavor, dealing as they did “with the interrelations between economic, social and political processes” (Lindbeck, 2020, n.p.). Hayek was in fact well known for his contributions to political theory, psychology, and economics (“Friedrich August Hayek,” n.d.). In 2002, psychologist Daniel Kahneman received the economics Nobel for empirical psychological research innovatively applied to behavioral economics (Lindbeck, 2020, n.p.). In 2008 Paul Krugman won the prize for integrating “the previously disparate research fields of international trade and economic geography” (NobelPrize.org, 2008).

If integrative work across disparate domains by Nobel laureates in economics is wide-ranging (with forays into law, history, psychology, geography, ecology, evolution, sociology, and philosophy), so, too, is the integration of specialties within economics itself. Theodore W. Schultz won the prize in part because “he does not treat agricultural economy in isolation, but as an integral part of the entire economy” (Press release, 1979). Gerard Debreu was similarly cited for merging “[w]ithin the same model . . . the theory of location, the theory of capital, and the theory of economic behaviour under uncertainty” (Press release, 1983). Richard Stone’s 1984 Nobel Prize cited his “full integration” of economic measures previously treated separately (NobelPrize.org, 1984). And the Committee noted of Finn E. Kydland’s and Edward C. Prescott’s 2004 Nobel Prize, that, “the Laureates . . . transformed the theory of business cycles by integrating it with the theory of economic growth” (Press release, 2004).

Nobel Prizes in the sciences also tend to go to those who fuse knowledge across disciplines, even though they are nominally given within the established categories of “Physics,” “Chemistry,” and “Physiology or Medicine.” Of the first thirty Nobel Prizes awarded in chemistry, four awards – those honoring van’t Hoff, Svante Arrhenius, Wilhelm Ostwald and Walther Nernst – went to pioneers of the new field of physical chemistry, which merged these two sciences for the first time; nine further awards went to Emil Fischer, Eduard Buchner, Richard Martin Willstätter, Fritz Pregl, Heinrich Otto Wieland, Adolf Windaus, Arthur Hardin, Hans Karl August Simon von Euler-Chelpin, and Hans Fischer who were the pioneers of biochemistry, a new field synthesized from biology and chemistry. Yet another dozen Nobel Prizes followed upon the integration into chemistry and medicine of award-winning physics inventions such as x-ray crystallography and nuclear magnetic resonance, which created the new disciplines of biophysics and molecular biology. Finally, during those first 30 years, five awards in physiology or

medicine recognized the integration of immunology with medicine: those to Emil von Behring, Ilya Metchnikoff and Paul Ehrlich, Charles Richet, Jules Bordet, and Karl Landsteiner. Another prize to Albrecht Kossel in 1910 recognized the medical applications of biochemistry. Then in the next two decades (1930–1950), the integration of genetics into medicine and physiology resulted in a dozen more Nobel Prizes and the combination of genetics and chemistry into biotechnology in yet another dozen.

No surprise, many of the “motivations” and rationales for Nobel Prizes in the sciences explicitly refer to field integration. Biographical information on the Nobel website for Walter Hess, physiology or medicine laureate for 1949, cites his integrative contribution as “bridging the gap which, until then, had yawned between physiology and psychiatry” (NobelPrize.org, 1949). Similar information on Allan M. Cormack and Godfrey N. Hounsfield [Med 1979] cites their pioneering work “integrating X-rays with digital technology to generate three-dimensional views of inner organs and soft tissues” – what we now routinely refer to as computed tomography or CAT scans (Pietzsch, 1979, n.p.). The rationale for awarding the 2000 Nobel Prize in Chemistry to Alan Heeger, Alan MacDiarmid, and Hideki Shirakawa for discovery of electrically conducting plastics likewise focused on the transfer of ideas and techniques across scientific domains: “The choice is motivated by the important scientific position that the field has achieved and the consequences in terms of practical applications and of interdisciplinary development between chemistry and physics” (Nobelprize.org, 2000a).

Like many economists, many science laureates received their Nobels for integrating specialties within one science domain as well. The award-winning work of Donald Cram, Jean-Marie Lehn, and Charles Pedersen [NP 1987] integrated “coordination chemistry, organic synthesis, analytical chemistry and bioorganic and bioinorganic chemistry, and has thus laid the foundation for the active interdisciplinary area of research within chemistry that has now come to be termed host-guest chemistry or supramolecular chemistry” (Press release, 1987). Similarly, Martin Karplus, Michael Levitt, and Arieh Warshel “successfully developed methods that combined quantum and classical mechanics to calculate the courses of chemical reactions using computers” (NobelPrize.org, 2013).

The one Nobel Prize category for which there is limited evidence that cross-disciplinary integration at a purely intellectual level has been an important factor are the peace awards. Most peace prizes recognize successful *social* efforts to bring together disparate groups of

people (rather than groups of ideas or concepts or methods) or to bridge cultural divides, whether these involve a de-escalation of hostilities or an extension of voting rights or civil justice to marginalized communities. To this end, Nobel Peace Prize “motivations” tend to highlight the founding of a new organization, the bringing of a new set of diverse actors to the table, or a new awareness creating politically stabilizing conditions through mediations involving previously non-communicating groups. In this sense, most peace prizes are intrinsically trans-cultural and trans-national if not explicitly transdisciplinary. Nevertheless, the Nobel Peace Prize has at times depended upon the integration of knowledge, skill, and concern across professional silos as well.

In 1911 lawyer and politician Tobias Asser received the peace prize for “his role as co-founder of the *Institute de droit international* . . . and [as] pioneer in the field of international legal relations” (NobelPrize.org, 1911a). In 1930 Nathan Söderblom, professor of theology and the first clergyman to receive the peace prize, applied his religious knowledge and training to creating “an international system of justice and arbitration” (ibid.). In 1962, Linus Pauling, a scientist who had previously won the Nobel Prize in Chemistry [NP 1954], received the peace prize “for his fight against the nuclear arms race between East and West” (NobelPrize.org, 1962). Similarly, Norman Borlaug’s 1970 peace prize brought the science of agricultural innovation to bear on global hunger. He received the award for developing robust strains of wheat that directly enabled many countries to feed their growing populations (NobelPrize.org, 1970a). Muhammad Yunus received the peace prize in 2006, along with the Grameen Bank he founded, for the social impact of economically innovative microcredit loans as a means of driving development in impoverished areas (NobelPrize.org, 2006). In each of these cases, prize committees recognized that the application of legal, religious, scientific, or economic know-how to social and political problems had had highly transformative results.

In sum, Nobel Prizes are frequently made to individuals or groups that integrate previously disparate specialties (and in the case of peace laureates, politically disparate actors and institutions) and, just as frequently, this integrative work has been done by individuals combining personal interests across fields of endeavor. Obviously, multidisciplinary is not a requirement for receiving a Nobel Prize – disciplinary specialists also receive the award (Root-Bernstein & Root-Bernstein, 2020b). Other considerations, having to do with gender, geography, and world politics, also play a large role in the nomination and selection process (McGrayne, 2001;

R.Friedman, 2001; Wires, 2009; Offer & Soderberg, 2016). However, the fact that awards committees frequently mention integrative qualities in the work of awardees suggests an implicit recognition of connection between multidisciplinary and highly creative endeavor.

The polymathic strategy: Nobel laureates explain themselves

The third type of phenomenological data that addresses the relationship of polymathy to the productive work of Nobel laureates are statements by these laureates about whether their multiple talents and skills intentionally served some creative goal. For purposes of simplicity and clarity, in what follows we have organized these autobiographical descriptions into the four Nobel categories of literature, economics, sciences and peace, saving an analysis of their similarities and differences for the Discussion section.

The uses of polymathy by literature laureates

It is a much-repeated observation that many successful writers, including Nobel laureates in literature, are “doubly-gifted” in the visual and verbal arts and often use the one to explore the other (Hjerter, 1986; D. Friedman, 2007; Huw & Pullman, 2018). Ivan Bunin [NP 1933] spoke of an early passion for painting which, he claimed, still “shows in my writings” (NobelPrize.org, 1933). Odysseus Elytis [NP 1979] explained that “after poetry, painting was my greatest passion” (cited in D. Friedman, 2007, 120). He illustrated his books of poetry with his own gouache paintings and collages, melding his two arts for greater effect. Claude Simon [NP 1985], who originally trained as a painter, fused the compositional processes of the visual arts to that of the novelist, and in so doing generated the experimental form of his narratives: “I write my books as one would create a painting,” he remarked. “Any painting is above all a composition” (cited in Pribic, 1990, 401). Hermann Hesse [NP 1946] initially took up watercolors in mid-life as a means of dealing with debilitating depression. The art soon became an all-consuming avocation, however, not only for its relaxing powers, but for its stimulation of his writing. Painting had a “similar tension and concentration,” which involved keeping in mind what was not yet painted, what was invisible to “the whole picture and to take them into account, to experience the whole fine network of intersecting vibrations” (Hesse-Foundation, n.d.). “Without painting,” he confessed, “I would not have come so far as a writer” (ibid.).

The practice of visual arts also afforded literature Nobels promising perspectives on literary experimentation. Yasunari Kawabata [NP 1968] wrote in a minimalist style that he learned from early exposure to and love for the traditional visual art of Japan. “The heart of the ink painting,” he observed, “is space, abbreviation, what is left undrawn” (cited in Larsson, 2006, 75). The same spareness and simplicity, along with what remained unspoken, characterized his novels and very brief “palm-of-the-hand-stories.” Earlier laureates also drew on the visual arts for inspiration. Par Lagerkvist [NP 1951] formally compared the techniques of writing and painting in one of his earliest books and modeled his writing on cubism, “dividing and relocating aspects of reality in order to arrive at a deeper and less obvious reality” (cited in Draugsvold, 2000, 67). And the poet Wisława Szymborska [NP 1996] periodically shut herself away to construct postcard collages, drawing on the “unserious” nature of this hobby, along with her penchant for writing “unserious” limericks, to (as one scholar put it) “[hunt] for ideas using appropriate – or frequently, the only available – tools” (Potocka, 2014, 59).

Dario Fo [NP 1997] provides another case in point. He trained as a visual artist at one of Italy’s most prestigious academies of art before turning to theater. Both fields of activity remained tightly twined for him, though the first as a professionally trained avocation, the second as an avocationally-acquired vocation. As Fo explained the interleaving of his arts, “Sometimes I draw my plays before I write them, and other times, when I’m having difficulty with a play, I stop writing so that I can draw out the action in pictures to solve the problem . . .” (cited in D. Friedman, 2007, 132). Indeed, he used drawing and painting to think out much of what he had to say – his Nobel acceptance speech consisted of twenty-five pages of colorful drawings in order, he told the assembled dignitaries, “to exercise my imagination – and to oblige you to use yours” (Fo, 1997, n.p.).

Günter Grass [NP 1999] experienced a similar synergy. Originally trained as a stone mason, he also attended art school, worked as a sculptor, and eventually published his first book of poems with pen and ink drawings. These were, in his own words, “no mere illustrations: they were a graphic anticipation and continuation of the verse . . . Word and image flow from the same ink in a highly personal and concrete take on the world” (Grass, 2007, 414). Indeed, he insisted, in the progression of his interests and activities, he had “not so much abandoned the world of earthy clay and plaster dust as expanded into the field of literature. This is known as the split in gymnastics” (ibid., 416). Many Nobel laureates have had their feet planted across similarly wide disciplinary divides.

Such combinations of a passion for one art combined with a compelling need to practice another is often referred to as a “violin d’Ingres,” after the painter Jean Ingres who initially trained as a violinist and played throughout his life (Tréguer, 2018). For some, the musical influence was implicit. Herman Hesse [NP 1946] expressed an affinity with music that was “intimate and fruitful. It is found in most of my writings” (NobelPrize.org, 1946). Harold Pinter [NP 2005] was deeply interested in jazz and classical music and felt “a sense of music continually in writing” (Plimpton, 1967, 354). Eugenio Montale [NP 1975], who was not only a poet and an amateur musician but also, in his words “a librarian, translator, literary and musical critic” as well as politician, also felt the music in the writing (Montale, 1975). Once asked how he managed to find the time for all his activities, he explained their analogical relationship: “Slowly poetry becomes visual because it paints images, but it is also musical: it unites two arts into one” (ibid.).

Yet other literature laureates fused writing and music in more technical terms. Passionate about his gramophone and records, Thomas Mann [NP 1929] used music listening as a stimulus to composition – and something more. Having played the violin and piano well into young adulthood, it came naturally to him to refer to his creative writing as “music-making” (cited in Prater, 1995, 75) and to transfer musical techniques such as the leitmotif into language in order to create, as one biographer put it, a “contrapuntal interweaving” of literary themes (Prater, 127). T.S. Eliot [NP 1948], an avocational pianist, wrote at length on poetry as an aural and emotional experience (Stead, 1968, 222). Study music, he argued, and learn how to use rhythm and structure, how to transition between themes to make meaning with images and words (Kermode, 1975, 113–114). Music certainly suggested certain innovative techniques in poetry for Boris Pasternak [NP 1958]. “More than anything else in the world I loved music,” he recalled of his early years as a student (cited in Pribic, 1990, 318). And though he turned decisively from performance and composition in his early twenties to writing, never again to practice music in any public way, the art stayed with him. In his writing, and especially in his early poetry, he often sacrificed literal meaning to “the sound of the word; startling rhymes, a repetition of the same morphemes, and other technical innovations” derived from his practice of musical composition (Pribic, 1990, 319).

Along with the brush and the violin, some literature laureates have also wielded the concepts and content of science (Root-Bernstein & Root-Bernstein, 2004). Frans Emil Sillanpää [NP 1939] incorporated the insights of

biologist Ernest Haeckel and chemist Wilhelm Ostwald [NP 1909] “and their theories about the unity of all nature in terms of physical laws” into his literary work (Liukkonen & Pesonen, 1997–2017). Similarly, for Johannes Jensen [NP 1944], “The grounding in natural sciences which I obtained in the course of my medical studies, including preliminary examinations in botany, zoology, physics, and chemistry, was to become decisive in determining the trend of my literary work” (NobelPrize.org, 1944b). In a cycle of six novels, translated into English as *The Long Journey* (1923–24), he transformed evolutionary principles into narrative structures and produced what was at the time considered “a daring and often impressive attempt to create a Darwinian alternative to the Biblical Genesis myth” (Johannes V. Jensen, 2021). George Bernard Shaw [NP 1925], playwright, polemicist, and music critic, was also a self-described “scientific biologist” or “metabiologist” (Pearson, 1950, 87). Between 1918 and 1920 he wrote a series of five plays set in past and future that explored the moral-biological evolution of humankind in Lamarckian terms still current at time of composition (“Back to Methuselah,” 2021). More recently, John Steinbeck [NP 1962] collaborated with the zoologist Edward Ricketts and incorporated holistic ecological thinking into the fiction that won him the Nobel in 1962 (Gilbert, 2002; Grant, 2019; Reis, 2015).

The uses of polymathy by economics laureates

As a group, economics Nobels have been particularly articulate about their multiple interests. As a discipline that found formal acceptance in the post-World War II years, it was inherently multidisciplinary, yielding to the analytical rigor and technique derived from math and physics and flowering with renewed examination of philosophical, historical, and psychological insights into human behavior. Indeed, many laureates in economics, intending to make a career in physics or mathematics, made the strategic decision to focus on a social science ready for scientific exploitation. Jan Tinbergen [NP 1969] turned from the study of physics to economics because of social concerns and a desire to do something useful for society. So did his fellow laureate, Ragnar Frisch [NP 1969]. Tjalling Koopmans [NP 1975] “first aspired to being a mathematician and then to being a theoretical physicist,” before finding “economics more challenging” (cited in Wahid, 2002, 100). Lawrence Klein [NP 1980] also switched focus because he had “some hunches about applications of mathematics to economics” (Hirsch & Breit, 2009, 18). Robert Engle III [NP 2003], too, transferred from physics to economics, bringing with him a deep and different understanding of how to integrate theory and data (Vane & Mulhearn, 2005, 322).

Maurice Allais [NP 1988] had a similar story to tell. Like so many of his peers, he had trained in the sciences and engineering, and then moved into economics. He also maintained “parallel interests” (his words) – one in physics and one in history (Allais, 1989 5; NobelPrize.org, 1988b). Sure that the “confrontation” between disciplines “considerably improved” his work, he regularly transferred techniques from one field to another: “All econometric studies,” he wrote, “present methods of analyzing time series which apply equally to geophysics. Likewise, geophysicists have studied analogous problems, and the methods they have developed can only be of the greatest benefit to economists” (1989, 11). Though it ranged over three very distinct fields of endeavor, his “passion for research” was, in his own words, variously “inspired by the *same conception* (Diemer2009, 101; Allais, 1989, 11). In physics and in history, as in economics, his goal was to understand “hidden periodicities,” whether these involved physical pendulums, monetary cycles, or the rise and fall of civilizations (Allais, 1989, 11). Indeed, Allais confessed to a “preoccupation with synthesis,” with the notion that his work, ranging as it did across the humanities, social sciences and sciences, contributed to a unified theory of knowledge (ibid.).

As Allais’ example makes clear, economics laureates were apt to harness the humanities as well as the sciences to their professional profile. Regarding his own attraction to economics, Joseph E. Stiglitz [NP 2001] explained:

I thought it provided an opportunity for me to apply my interests and abilities in mathematics to important social problems, and somehow, I thought it would also enable me to combine my interest in history and in writing. I wanted it all, and economics seems to have it all. (NobelPrize.org, 2002)

Other Nobel laureates in economics reasoned similarly, in act if not in word, by combining multiple interests across multiple domains. Simon Kuznets [NP 1971], in the words of fellow laureate Robert Fogel, proved “erudite not only in economics, but also in history, demography, statistics, and the natural sciences” (NobelPrize.org, 1993b). Daniel McFadden [NP 2000] ranged across physics, economics, psychology, sociology, anthropology, political science, math, and statistics (Vane & Mulhearn, 2005, 286). Jean Tirole [NP 2014] considered it an important opportunity “to take a number of specialization courses (macroeconomics, public economics, international economics, etc.) in fields not directly related to my thesis. In economics, research fields change quickly and multidisciplinary knowledge is often essential to bring fresh thinking” (NobelPrize.org, 2014a).

While most economics laureates confined their extracurricular interests to knowledge disciplines in the sciences, social sciences, and humanities (Root-Bernstein & Root-Bernstein, 2020b), some also explored a broad range of avocational activities in the arts and elsewhere. Douglass North [NP 1993] maintained lifelong interests in music appreciation, fishing, hunting, flying, and especially photography, in which he showed such early promise he considered pursuing it as a career (NobelPrize.org, 1993a). Eric Maskin [NP 2007] similarly dedicated himself to the serious amateur pursuit of music, including public performances on the clarinet as part of a chamber ensemble (NobelPrize.org, 2014b). And Herbert Simon [NP 1978] famously devoted himself to as many hobbies as he did fields of social science and humanities. These included chess, piano playing, musical composition, drawing, and painting (Simon, 1996, 240–243). Simon referred often to the intellectual excitement as well as pleasure he derived from crossing vocational with avocational fields (1996, 363–364): “I can rationalize any activity I engage in as simply another form of research on cognition,” he wrote. “I can always view my hobbies as part of my research” (1996, 243).

Simon’s ability to integrate all his interests suggests that there is something about being a generalist that supported his creative insights. Certainly, the theme of purposefully being a generalist runs through the autobiographical writings of many economics laureates. Paul Samuelson [NP 1970] described himself as “the last ‘generalist’” in “this age of specialization” (NobelPrize.org, 1970b), listing interests that ranged from mathematical economics and financial journalism to research and teaching. Indeed, he seems to have steeped himself – as did other eventual laureates in economics – in the portrait of the “master-economist” drawn by J. M Keynes:

[T]he master-economist must possess a rare combination of gifts. He must reach a high standard in several different directions and must combine talents not often found together. He must be mathematician, historian, statesman, philosopher—in some degree . . . He must contemplate the particular in terms of the general, and touch abstract and concrete in the same flight of thought No part of man’s nature or his institutions must lie entirely outside his regard . . . (Keynes, 1924, 322)

Like Keynes, economics laureate Friedrich Hayek [NP 1974] once remarked that “[n]obody can be a great economist who is only an economist” (cited in NobelPrize.org, 1974). Maurice Allais [NP 1988] recommended that the master economist must resist excessive specialization and opt instead for the “broad perspective of history, sociology, and political science” (Allais, 1989, 14). These self-reported rationales for being

multidisciplinary certainly coincide well with the statistical observation that 92% of economics laureates have formal training in more than one knowledge domain and over half have also been intra-domain polymaths (Root-Bernstein & Root-Bernstein, 2020b).

The uses of polymathy by science laureates

Although modern science is largely characterized by the splintering of fields and increasing specialization (de Solla Price, 1963; Root-Bernstein, 1989), many Nobel laureates in physics, chemistry and physiology or medicine have espoused multidisciplinary and transdisciplinary integration as strategies for discovery. Some have found the necessary combination of breadth and depth necessary to plough new ground through collaborative work. Herbert Hauptman, who jointly won the Nobel Prize in Chemistry in 1985 with Jerome Karle, recognized this explicitly:

We were fortunate, too, that our particular qualifications, Jerome Karle’s in physical chemistry and mine in mathematics, were the exact *combination* which was needed to enable us to tackle, with some hope of success . . . [a] major stumbling-block in the solution of crystal structures by the technique of X-ray diffraction. (NobelPrize.org, 1985b)

Similarly, Satoshi Ōmura [Med 2015] makes clear in his Nobel autobiography how collaborations made possible many of his important discoveries and emphasizes “his commitment to engage and groom young researchers . . . with respect to scientific research, multidisciplinary collaborations and the fundamental importance of good interpersonal associations in working partnerships” (Nobelprize.org, 2015).

For most science laureates, however, specialization in breadth has been a personal achievement. Gertrude Elion [Med 1988], who never earned a doctorate, nonetheless constantly added new disciplines to her repertoire as an organic chemist: “I never felt constrained to remain strictly in chemistry, but was able to broaden my horizons into biochemistry, pharmacology, immunology, and eventually virology” (NobelPrize.org, 1988a). The dual prize winner Linus Pauling felt similarly unconstrained by specialization:

I have always wanted to know as much as possible about the world . . . Usually I say I am a chemist; sometimes I say I am a physical chemist . . . My scientific work, however, has extended over x-ray crystallography, mineralogy, biochemistry, nuclear science, genetics, and molecular biology; also nutrition and various aspects of research in medicine, such as serology, immunology, and psychiatry. So, more recently I call myself simply a scientist. (Pauling, 1995, 26)

Wolfgang Ketterle, a physics laureate [NP 2001] who built his career on changing fields, similarly relied on broad training to do so. “Amazed to see how much of what I had learnt before could be applied within the new field, I realized that general skills are much more important than specific knowledge” – indeed, he argued, general skills cut the time it took him to reach productivity and leadership in new areas of interest (NobelPrize.org, 2001). Frank Wilczek, yet another laureate in physics [2004], also purposefully maintained intellectual interests in a broad range of fields: “To me, the unity of knowledge is a living ideal and goal. I continue, as in my student days, to read voraciously in many subjects . . . to further expand the horizons of my writing and work . . . ” (NobelPrize.org, 2004b). Konstantin Novoselov [Physics 2010], echoed this sentiment: “You think that we’re doing physics, [but] we’re not, we’re actually doing *science* and this means that our interests are much, much broader than . . . physics by itself, so we just try to be curious in everything . . . ” (NobelPrize.org, 2010).

For many science laureates, breadth of interest very much included avocational engagement, often enough at levels of considerable mastery. T. W. Richards [Chemistry, 1914], an excellent painter and musician, was once asked how to spot “the best chemist in any gathering.” He answered: “I should find out first who played the ‘cello best” (Gordon, 1932, 366). There appears to be validity to his seemingly outrageous over-simplification. Wilhelm Ostwald [Chemistry 1908], Walther Nernst [Chemistry 1920], Albert Einstein [Physics 1921], Louis de Broglie [Physics 1929], Werner Heisenberg [Physics 1932], Ernst Chain [Med 1945] and many other laureates played instruments at semi-professional levels. Max Planck [Physics 1918] played piano, ‘cello, composed songs, and even wrote operas, hosting regular musical soirees for his physics colleagues throughout his life (Meissner, 1951, 75). Edmond H. Fischer [Med 1992] began training for a professional career as a pianist at the Geneva Conservatory of Music before deciding that science was a more stable career path (NobelPrize.org, 1992). Hugo Theorell [Med 1955] played violin “with world famous artists like Isaac Stern and Enrico Mainardi, or with other musically talented Nobel Laureates such as Ernst Chain and Manfred Eigen” (Theorell, 1955). For his part, Eigen [Chemistry 1967] also sometimes accompanied Rudolf Serkin, considered to be the premier 20th century interpreter of Beethoven’s piano works; Eigen’s own piano performances merited release as recordings on major studio labels (DeVoto, 2019).

In many cases, musical knowledge and techniques acquired in avocation played a significant role in scientific creativity. Eigen’s prize-winning innovation involved directing specific frequencies of sound at chemical reactions, thus permitting their ultra-fast reaction rates to be measured for the first time (NobelPrize.org, 1967). His concept of virus quasi-species as the source of evolutionary variations has also been traced to musical concepts of variations on a theme (DeVoto, 2019). A generation earlier, Albert Einstein [NP 1921] had found similar professional benefit in avocational activity. “The theory of relativity occurred to me by intuition,” he once explained, “and music is the driving force behind this intuition. My new discovery is the result of musical perception” (Suzuki, 1969, 90) For his part, the music-immersed physicist Max Planck [NP 1918] had studied the physics behind “natural” and “tempered” piano tunings. His subsequent theory of the quantum originated in an analogy between electrons and vibrating musical strings (Pisek, 2014, 257; Kuhn, 1978). Similarly, de Broglie’s discovery of wave-particle duality originated in the recognition that if electrons really did behave like musical strings, then these particles should emit overtones and resonances just like a musical instrument (Pisek, 2014). It is hardly surprising, therefore, to find Einstein proclaiming that “[t]he greatest scientists are artists as well,” (2000, 155, 245) and Planck writing that “[t]he creative scientist needs . . . an artistic imagination” (1949, 14).

Music is not, of course, a prerequisite to scientific or any other type of creativity. Many scientific Nobel laureates have been visual artists, sculptors, poets, playwrights, novelists, and craftspeople (Root-Bernstein, 1989; Root-Bernstein, Bernstein, & Garnier, 1995; Root-Bernstein & Root-Bernstein, 2020b, 1999). For some, as we will discuss at greater length below, these avocations were a way to renew creative energy, while for many there were direct, if unexpected connections to their scientific work. Georg von Békésy [Med 1961], another scientist whom colleagues described as a “Renaissance” intellect (Ratliff, 1974), cultivated interests in music and in art as a means of aesthetic and perceptual training: “Comparing one art object with another to determine quality and authenticity, he thought, greatly improved his ability to make judgements about the quality of scientific work too . . . ” (Ratliff, 1974, 31–32).

More generally, many Nobel laureates have pointed to the broad sets of scientifically relevant skills trained by avocations (Root-Bernstein, 1989; Root-Bernstein & Root-Bernstein, 1999). J. H. van’t Hoff, the first prize winner in chemistry [1901], made seminal contributions to physics, chemistry, biochemistry, geology, and oceanography and still made time to write poetry, paint, and

play the flute. He argued from a study of over 200 scientific biographies and autobiographies that scientific imagination always developed hand-in-hand with serious engagement in other disciplines such as music, the arts, literature, philosophy or even religion (van't Hoff, 1967). Santiago Ramon y Cajal, [Med 1906], a champion gymnast, extraordinary artist, professional photographer, short story writer, and neurologist, reached the same conclusion. “The investigator,” he wrote, “should possess . . . an artistic temperament which impels him to search for, and have the admiration of, the number, beauty, and harmony of things” in “all the recreations of mind and body” (Ramon y Cajal’s, 1951, 34)

Donald Cram [Chemistry 1987] certainly fit Ramon y Cajal’s prescription: He once remarked that science was a “great way of combining” the use of the intellect and of the hands. An avid surfer as well as amateur musician who played his guitar and sang at conferences, he described his “concept of the ideal person” as someone who specializes in one thing and then does a lot of other things “but not too many, maybe five or six or ten . . . “ spread widely “among sports and artistic things and carpentry and things that involve using your hands and a little music perhaps . . . ” (Root-Bernstein et al., 1995; Warshaw, 2010, n.p.). Like Cram, Christiane Nüsslein-Volhard [Med 1995] has also combined intellect, hand, and heart – as a biologist, but also as artist, puzzle designer, flutist, singer, and author of a best-selling cookbook (Brown, 2017). “I’m very curious and I like to understand things,” she has said, “and not only science . . . I also did music and I did languages and literature and so on” (Nüsslein-Volhard, 1995). Even after focusing on science, she tried a series of scientific disciplines – physics, physical chemistry, biochemistry – before finally settling on embryology, where her diverse training resulted in eminently novel questions, techniques and results. She has advised students today to develop a similarly broad and idiosyncratic study: “You should, as far as possible, avoid mainstream areas and change fields after your PhD in order to be able to develop an independent profile and work on an original, self-selected topic” (Brown, 2017).

Broad-ranging curiosity of the sort profiled above does not dilute the power of scientific creativity but channels it in novel directions. Due to their idiosyncratic backgrounds, Nobel laureates find unexpected problems at the intersections of fields; they make inroads on scientific knowledge with unusual combinations of ideas, techniques, methods, concepts, and theories. Alexis Carrel [Med 1912] adapted his lacemaking and embroidery skills to develop the novel surgical stitching techniques that earned him his Nobel Prize (Edwards & Edwards, 1974). Alexander Fleming [Med 1945] owed

his discovery of penicillin to an avocational habit of collecting brightly colored microorganisms with which to make microbial paintings (Root-Bernstein, 1989). And Alan McDiarmid [Chemistry 2000] has stated that his discovery of electrically conducting plastics was driven purely by aesthetics: “My motivations have been driven by curiosity and color . . . There were no scientific reasons whatsoever” (Russo, 2000, n.p.). Similarly, C. T. R Wilson [Physics 1927] made the first cloud chamber not for scientific reasons but, after hiking Ben Nevis in Scotland, to recapture the beauty of glories, those circular rainbow-colored rings that form on clouds, and the so-called Brocken spectre (the shadow of the observer) that sometimes appears at their centers (Wilson, 1959). Only later did he turn to the role of ionizing radiation in forming these clouds and to the observation of subatomic particles. Harry Kroto’s path to the Nobel Prize in Chemistry [1996] was equally convoluted. He spent the first half of his career conflicted about whether to remain a chemist: “I remember thinking I would give myself five years to make a go of research and teaching and if it was not working out I would re-train to do graphic design (my first love) . . . ” (NobelPrize.org, 1996). Meanwhile, he contemplated apprenticing himself to the architect/designer R. Buckminster Fuller. Fuller’s geodesic dome structures subsequently inspired Kroto’s discovery of a new class of chemical compounds with geodesic structures that he aptly named “fullerenes.”

In sum, as previous statistical studies have demonstrated (Root-Bernstein et al., 2008, 1995; Root-Bernstein, Bernstein, & Schlichting, 1993; Root-Bernstein & Root-Bernstein, 2004, 2020b), arts, design, crafts, and music have played an outsized role in the intellectual accomplishments of Nobel Prize winners in the sciences, as has formal training in more than one scientific field.

The uses of polymathy by peace laureates

As noted above, tracking the polymathic strategy among peace laureates is somewhat different than it is for laureates in the sciences, in economics, or in literature. Very few peace laureates appear to have remarked explicitly on multidisciplinary *per se* or its relevance to their successful advocacy for arms control, international cooperation, or the cessation of hostilities. And yet, some among them have engaged in and remarked on the inspired crossing of activity domains.

Dag Hammarskjöld was one of these. Hammarskjöld reaped multiple benefits from multiple vocational and avocational activities that he considered mutually supportive. Keeping a diary and composing haiku provided a private emotional retreat from the pressures of his

high-profile diplomatic work. Mountaineering served him “as a recurrent metaphor” suggestive of diplomatic strategies for finding indirect routes around insurmountable obstacles (Lipsey, 2013, 35). And photography allowed him to “reach a kind of self-fulfillment, both technical and aesthetic” in much the same way as any creative artist (cited in Falkman, 2005, 221). It also taught him to see, literally and figuratively, beyond the obvious. In an essay looking back on his own “perennially active interest in photography,” Hammarskjöld remarked that “in the final analysis we learn more from our own than any number of pictures by the true artists of the camera, however great our debt of gratitude for their guidance” (cited in Falkman, 2005, 222).

At times, all his avocations came together to inform Hammarskjöld’s work. As Secretary General he had opportunity to help choose artwork for that institution – one such being “Single Form” by the sculptor Barbara Hepworth. In response to its “great beauty,” its “deep quiet and timeless perspective in inner space” (cited in Falkman, 2006, 158), Hammarskjöld wrote a series of haiku. He wrote to the sculptor as well of his faith that the U.N. might “model in action and words what you are so fortunate to express, to perfection, visibly and tangibly” (cited in Falkman, 2006, 157). As Brian Urquhart, his Under-Secretary, remarked: “Of all the people I have known, Hammarskjöld was by far the most successful in organizing his public life and his widespread intellectual, spiritual and aesthetic interests into an integrated and self-sustaining pattern” (2011, A19).

Historian and political scientist Christian Lous Lange [NP 1921] similarly used his interest in biology to strengthen the political case for the League of Nations and other like institutions. As an influential advocate and author on the subject of “internationalism,” he grounded the “unity of mankind” not just in moral or sociological terms, but in the biological continuity of “the living germ plasm” of sperm and egg: “Each of us is, literally and physiologically, a link in the big chain that makes up mankind ... [I]f mankind is a physiological entity, then war – international war no less than civil war – is suicide, a degradation of mankind” (Lange, 1921, n.p.). The law scholar and diplomat Mohamed ElBaradei also applied professional training to cross-domain challenge. “I guess I thought law would give me the opportunity to work as a social engineer, if you like, to try to develop a society that is free, that is at peace with itself” (Academy of Achievement, 2006). He effectively parlayed his advanced study of international law, arms control, and the peaceful uses of nuclear energy into three terms as Director General of the

International Atomic Energy Agency, for which leadership he and the IAEA jointly received the peace prize in 2005.

For Jason Shogren [Peace 2007] vocation and avocation all came together when a series of family crises led him to a career-altering realization. People do not entirely behave in economically rational ways, as he had been taught. “In my mind missing something that big suggested that I had a huge hole in my development.” As a result, he began to read poetry and write and perform music to better understand the non-rational aspects of life that he had been ignoring. “I opened the door back up to music and it was like opening a lock at high water. It just filled up” – transforming both his life and policy making (Storrow, 2013).

For many peace laureates, generally more interested in social action than academic theorizing, polymathic connections may also be traced in the functioning engagements of serial or multiple careers that produced unexpected connections and insights. Adolfo Perez Esquivel [NP 1980] was a successful sculptor and art teacher for fifteen years before he became a political activist. Significantly, it was his professional interest in pre-Columbian art that introduced him to the poverty and oppression of indigenous peoples in Latin America and launched his second career coordinating a web of regional organizations promoting non-violent liberation and human rights (Abrams, 2012, 246; NobelPrize.org, 1980). Other laureates parlayed careers in the arts, humanities, or sciences into peace work at local, regional, and national levels. Emily Greene Balch [NP 1946], for one, had at least three careers: as an economics professor at Wellesley, aiming to “awaken the desire of women students to work for social betterment”; as a founder of Denison House, one of the first settlement houses in the U.S.; and as a leader of the Women’s International League for Peace and Freedom between World Wars I and II (Abrams, 2012, 153–154). Balch, like Jane Adams [NP 1931] before her, successfully transposed the community-building of Denison House (and Adams’ Hull House) into proactive plans for world peace, ultimately creating and participating in wholly new civil initiatives to effect international politics (Larsson, 2006, 141).

In sum, for peace prize winners it was not the content of their polymathic endeavors that most informed their prize-winning innovations but more often the experiences of the world that they gained through these endeavors that identified specific problems to be solved and provided sets of honed skills to apply to their amelioration. In this sense, polymathy may be the outcome of a series of life experiences rather than merely the mastery of diverse sets of disciplinary knowledge and skills.

Discussion

Various patterns emerge from evidence of Nobel polymathy. Perhaps the most striking is that many laureates express the view that their multiple vocations, or mixes of vocations and avocations, have functioned to stimulate their professional creativity. Moreover, these self-evaluations are often echoed by colleagues and by the Nobel Prize selection committees as well. These qualitative types of evidence synchronize with the quantitative data correlating Nobel Prizes with trans- and intra-domain polymathy (Root-Bernstein et al., 2008; Root-Bernstein & Root-Bernstein, 2004, 2011, 2020a, 2020b). They also corroborate previous studies of the role that transdisciplinary patterns of activity play in the work of highly creative individuals more generally.

Dewey (1934), Gruber (1974; 1989), and R. Root-Bernstein (1989) all noted that extraordinarily creative people develop integrated networks of enterprise through the development of correlative talents that permit them to transcend disciplinary boundaries and thought patterns. A good deal of this previous work was done by looking at the careers of scientists (Gruber, 1974, 1989; R. Root-Bernstein et al., 1995; R., 2008). The present study broadens these previous studies to encompass Nobel laureates in literature, economics, and peace and to characterize ways in which networks of interest differ significantly by their professional groupings. While scientists tend to integrate arts, music, and crafts into their vocational networks and ignore the humanities and social sciences, economists are much more likely to meld mathematical and scientific skills with interests in humanities and social sciences and (relatively speaking) ignore the arts. Literature laureates, in turn, weave together literary, artistic, and sometimes scientific interests, while peace prize winners tend to integrate humanistic and social science concerns with literary ability (and to a much lesser extent, with arts and sciences) (Root-Bernstein & Root-Bernstein, 2020b). Not only does each Nobel group exhibit a distinct pattern of vocational-avocational activity, but each individual within each group displays a particular networking of interests. Different as these correlative talents may be by group and by individual, however, these polymathic Nobel laureates share generally in the optimization of their creative ability. Indeed, both integration and optimization of interest networks differentiate such highly creative individuals from the typical professional in each of these domains (R. Root-Bernstein et al., 1995; Root-Bernstein & Root-Bernstein, 2020b).

That serious *avocational* engagement may bring as much to a network of enterprise as *vocational* interest bears repetition. Summarizing extant research, M. Root-Bernstein (2020) argued from phenomenological evidence that creative transfer between vocation and avocation can run in either direction when amateur engagement is understood as the systematic acquisition of special skills, experience, and knowledge at or approaching professional levels (M. Root-Bernstein, 2020). That said, in keeping with the idiosyncratic and personal nature of vocation-vocation or vocation-avocation networks, how or why the integration of interests may yield optimal creative productivity can vary from individual to individual.

The concept of integrated networks of enterprise, whether these networks remain within or cross domains and whether they involve avocational as well as vocational commitment, permits us to address one of the outstanding questions raised by previous statistical study of Nobel polymathy (R. Root-Bernstein et al., 2008; Root-Bernstein & Root-Bernstein, 2020b): What possible factors yield the strong correlations between interdomain and intra-domain polymathy and the very high level of creative success implied by the award of a Nobel Prize? Statistical correlations alone are amenable to at least three possible explanations: first, that Nobel Prize winners are simply smarter and more diversely talented than the average person; second, that Nobel laureates had better access to educational opportunities due to socioeconomic factors and/or educational opportunities; third, that broad-ranging polymathy is causally related to creative outcomes (of which, more below).

Because information about intelligence and educational and socioeconomic opportunities were not gathered as part of this study, we cannot discount the possibility that Nobel laureates are smarter and more talented than the typical professional. However, previous studies have addressed this question and have found that there is, at present, no evidence that Nobel laureates are more intelligent than the average professional (R. Root-Bernstein, 2015; Warne, Larsen, & Clark, 2020). Nor is there evidence that intelligence, whether measured by IQ (the intelligence quotient) (R. Root-Bernstein, 2015; Warne et al., 2020), the Miller Analogies Test (R. Root-Bernstein et al., 1993), or grades and standardized test scores such as the SAT (R. Root-Bernstein, 2015), correlates with professional measures of creativity. These studies find that Nobel laureates have the same range of test scores and grades as do their professional peers.

However, socioeconomic factors combined with educational opportunities almost certainly play some role in fostering the development of Nobel laureates. Rodríguez, (n.d.) found that in the sciences, Nobel laureates were more than twice as likely to come from families with above-average incomes than those with below-average incomes, but that this factor almost disappeared for literature, peace, and economics laureates. Berry reported similar findings in a 1981 study, adding that literature laureates were unique in that over 30% experienced the loss of one or both parents at an early age or the family went bankrupt or became impoverished. Poverty was rarer among other groups of Nobel Prize winners and almost non-existent among physics and economics laureates (Berry, 1981).

Both Berry (1981) and Rodríguez, (n.d.) found that the most striking socioeconomic factor among prize winners was the high percentage of academics and teachers among their parents: 31.4% of parents (father, mother, or both) were teachers for those who received a Nobel Prize in Physics, 20.2% for those in Chemistry, 21.5% for those in Physiology or Medicine. Rodríguez notes that “[t]his result highlights that parental occupation plays an important role for scientific careers not only because of the required economic resources, but also because of the transmitted values and beliefs” (2021, 7). The same might be said for careers in economics, literature or peace advocacy: 20.3% of parents were teachers for economics laureates, 15.8% for literature laureates, and 11.5% for peace laureates (Berry, 1981; Rodríguez, n.d.). Given that academics and teachers make up only about 3 to 5 % of the workforce in most developed nations (NationMaster, 1999), these percentages speak equally to significant educational and cultural largesse among Nobel Prize winners generally.

The question now becomes how Nobel laureates have chosen to use educational opportunity. Have they developed a broader-than-average range of interests passively, simply because they could or did they do so with intent? Why have so many trained themselves in multiple vocational fields or developed avocations sometimes to a professional level, or both? If so, how might this broad-ranging polymathy promote creative outcomes? To answer these questions, it is necessary to consider what laureates themselves say about the role of polymathy in their careers.

Nobel Prize winners justify their polymathic proclivities in one of four ways. First, knowledge is wholistic and to explore it otherwise is to miss essential insights and meanings. Second, creativity is intrinsically combinatorial, requiring trans-disciplinary integration. Third, what might be called the “novice effect,” the idea that

creative insights are more likely to occur to individuals new to a field than to experts long entrenched in it, means that there is value in constantly changing one’s focus. And fourth, recreation often leads to re-creation, such that creative activity in one area stimulates creative insights in another. All these justifications suggest at the very least a post-hoc attempt by laureates to understand polymathic proclivities as purposeful and useful strategies.

“I Wanted It All”

There is little doubt that many Nobel laureates have implicitly, if not explicitly, understood the concept of integrated networks of enterprise. Amongst literature laureates, Rabindranath Tagore considered his writings, songs, and paintings to be part of one whole, which he called his “self-creation” (Cuthbertson, 1968, 6). As a result, scholars have called out a “relational link” between “the diversities of his creative expression as a poet, thinker and artist” (ibid.). G. B. Shaw railed against critics and biographers who insisted on separating discussion of his writings about religion, politics, science, and music into “brain-tight compartments” (Pearson, 1950, 61). His explorations of music, “metabiology,” and politics were all one, for “in human nature they are all mixed up in different proportions, and that is how they are mixed in my plays” (ibid.). Economics laureate Herbert Simon also demonstrated an instinct for integration within and across fields. According to Wahid (2002), Simon “greatly appreciated and enforced the synergy between social and natural sciences throughout his life” (pp. 130, 134). By Simon’s own reckoning, the synergies went even farther than that – as mentioned above, he viewed his multiple avocations, too, as “part of my research” on cognition more generally (1996, 243). His network of interests was eclectic, yet of a piece: “[T]he ‘Renaissance Mind,’ he argued, “is not broader than other intelligent minds, but happens to cover a narrow swathe across the multi-dimensional space of knowledge” (cited in Frantz & Marsh, 2016, 1–2).

In Simon’s case that “narrow swathe” involved a focus on a single problem that cut across disciplines. “I am a monomaniac,” he remarked. “What I am a monomaniac about is decision-making” (cited in Frantz & Marsh, 2016, 2). Other laureates have similarly chosen to specialize in breadth. One preceptive critic argued that Octavio Paz was a “generalist” and that, “the role of the generalist is not simply to know a little bit about many subjects, but to be passionate and knowledgeable about many different things – in a sense, to be a multi-faceted specialist” (Stavans, 2001, 7–8). In

support of just such a goal, Ramon y Cajal opined that the greatest contributions to the sciences were likely to be made by avocational polymaths, those who took time to pursue literature, art, philosophy and other recreations of mind and body: “To him who observes them from afar, it appears as though they are scattering and dissipating their energies, while in reality, they are channeling and strengthening them” (1951, 170–171). Like Nüsslein-Volhard and other laureates, Ramon y Cajal saw creative benefit in such meanderings – this in contrast to average professionals who often attribute lack of career success to time wasted outside narrowly-focused study (R. Root-Bernstein et al., 1993).

For many a Nobel laureate, it is axiomatic that the “multi-faceted” generalist discovers among diverse passions some specialized connection. The polymathic path is for many a choice to maximize the use of as many interests as possible. As noted in Results, the economist Stiglitz “wanted it all.” So did chemist Cram, who welcomed the latitude he found in science to use his hands as well as his intellect (R. Root-Bernstein et al., 1995, 126). For his part, George Beadle [Med 1958], like economist Allais, noted that one career may not fulfill a polymathic individual: “Every scientist realizes in his science only a small portion of his total ability. I suppose that’s true in general – that you don’t do everything you’re capable of by a big factor. I don’t” (R. Root-Bernstein et al., 1995, 126–127). Beadle supplemented his research with popular science writing, artwork, and photography. Decades earlier, the chemist Ostwald had written impassioned essays about why art and music were so important to him, ruing the fact that science had become so objectivized as to almost dehumanize its practitioners (Ostwald, 1903, 18; see also, 1905, 16). He combined his painting avocation with a scientific approach to studying color and form, translated his insights into books designed to help artists achieve better results, and taught at the Bauhaus, a pre-eminent art and design school. Like Arrow the “systematizer,” like Allais the “synthesizer,” Ostwald’s goal was to unify. As one biographer put it, he “stands out as a phenomenal combination, not only of the scientist and the philosopher, also of artist, linguist, and writer, who squandering no energy, but conserving it, applied his major interests to one another” (Wall, 1948, 118).

Creativity is combinatorial

That Ostwald, Ramon y Cajal, Beadle, Cram, Simon, Allais, Stiglitz, Shaw, Tagore, and many other laureates sought to specialize in breadth suggests that their creativity may also stem from what may be called a “combinatorial” foundation. The idea that creativity

is combinatorial was first proposed among cognitive psychologists by Campbell in 1960 and has subsequently been developed and expanded by Thagard (2012) and Simonton (2010; 2021). Notably, the notion dates much further back among Nobel laureates themselves. Ostwald, for one, explicitly addressed the subject as early as 1903 (e.g., Hapke, 2012; Ostwald, 1978). “Combinatorics doesn’t only replace productive imagination, but is superior to it!” he exclaimed (Ostwald, 1978, 29). The philosophical basis for this remains sound. Logically, for a body of poems, say, or a theory, or a peace initiative, or a technical transfer to be creative (at least at the level of Nobel Prizes), it must be novel in a non-trivial way and effective in nature and/or society. In other words, it must combine previously disparate elements in new and unexpected ways to produce something that changes how people perceive, think, and act in the world.

People who are trained unusually, and unusually broadly, would appear to be more likely to have the intellectual, conceptual, methodological, technical, social, and emotional resources to produce such novel and effective combinations. Damian and Simonton (2014) have called such unusual backgrounds “‘diversifying experiences’ (i.e., experiences that disrupt conventional and/or fixed patterns of thinking, thus enabling a person to view the world in multiple ways)” and propose that they “are linked to more creativity” (n.p.). Conversely, people trained traditionally are likely to share common ways of thinking and acting and to produce similar ideas and artifacts. A study of the scientists who participated in the founding of biophysics during the mid-19th century found a direct correlation between the number of philosophical and artistic avocations each scientist had and the number of important contributions they made to the new discipline (Cranefield, 1966). The same phenomenon was revealed statistically in previous study of Nobels (Root-Bernstein & Root-Bernstein, 2020b) and emerges in the present qualitative one.

It comes as no surprise, then, that many Nobel laureates have expressed the belief that combinatorial processes lie at the heart of their creativity. Einstein wrote to his colleague Jacques Hadamard that, “taken from a psychological viewpoint, . . . combinatory play seems to be the essential feature in productive thought” (cited in Hadamard, 1945, 142–3). Pauling made a similar argument:

A person who commands several branches of knowledge transfers something that is well known in one area into other areas [where it is not well known]. The art of transferal constitutes an inspiration I have discovered many things This probably because I think

more about scientific problems than most other scientists. Another reason is my broad background of knowledge. This scope enables me to transfer facts from the field of physics to chemical problems to which they have never been applied before . . . My inspirational ideas have come from my great body of knowledge. (1995, 82)

Nobel laureates in economics appear particularly aware of the power of knowledge transfer from one field of interest to another – typically, in their case, from the natural to the social sciences, as the experience of Tinbergen, Frisch, Koopmans, Klein, and Engle make clear. Indeed, many expressed the same rationale as Robert C. Merton [NP 1997], who left engineering in graduate school after recognizing an intuitive “feel” for economic matters: “I also believed that my mathematics and engineering training might give me some advantage in analyzing complex situations” (NobelPrize.org, 1997b). After beginning a Ph.D. program in physics, McFadden, too, applied a broad range of social sciences to the mathematical modeling of learning and choice, explaining that though each discipline invariably speaks its own language, the problems they address are often essentially the same (Vane & Mulhearn, 2005, 286). Similarly, Robert Fogel [NP 1993] poured economic technique into historical research, notably so in his innovative, if controversial, study of ante-bellum slavery in the U.S. By his own account, he had purposefully trained himself as a graduate student in both history and economics in the “naïve belief that . . . I would quickly discover the fundamental forces that had determined technological and institutional changes over the ages . . . ” (NobelPrize.org, 1993b). As a full-fledged researcher, he continued to explore and to import ideas, analytical tools, and mathematical models from demography, epidemiology, and biomedical sciences such as auxology (the study of human physical growth) into his economic history (ibid.). This extensive knowledge transfer gave birth to a new economic history, sometimes called “cliometrics.” Few individuals, one colleague averred, “can claim to have had such an impact on an academic discipline” (Floud, 2013, n.p.).

Orhan Pamuk [Literature 2006], who had applied himself to the visual arts in youth, also spelled out certain aspects of this combinatory strategy for his work as a writer: “I strongly believe that creativity in literature comes from first an understanding that you have to put together two things that have never been put together and see if there is an electricity in between them” (cited in Engdahl, 2006). He himself had applied the approach to literary innovation. In the novel *The Black Book*, he took as subject the city of Istanbul, in itself a place “where layers of layers, things and images, history and myth combined,” and purposefully explored its mysteries in an unexpected style, an “experimental

post- modern European avant-gardism, all together with a classical Sufi text” (ibid.) The point was to “see what happens” when “things we at first think that [sic] are impossible to bring together or almost daring and scandalous to combine . . . [can be] the beginnings of good art . . . ” (ibid.).

The same combinatorial effects can be seen in the works of many other literature laureates (as well as in the reasons for their awards) – particularly for those who wove insights and techniques from visual, plastic, and musical arts into their literary masterpieces. Recall that the ongoing pursuit of multiple interests was, for Wisława Szymborska [NP 1996], a purposeful game plan: her cut-and-paste cards and her limericks, as well as her “serious” poetry, must be considered “as pieces of her whole creative output that justify one another and mutually support each other’s interpretations” (Potocka, 2014, 57). Her generative use of art—certainly present in the creative processes of Hesse, Eliot, Pasternak, Kawabata, Lagerkvist, Mann, Walcott, Fo, Grass, Pamuk, and Bob Dylan among others – raises questions “about the purpose of art in the private sphere” (Potocka, 2014, 55). This is especially so when a personally compelling interest is not transferred to the public sphere, but kept “amateur,” and yet can clearly be seen to shape professional output. Whether acquired professionally or avocationally, skills and knowledge that become part of an individual’s integrated network of enterprise do affect the nature and products of that enterprise.

The “novice effect”

A third possible explanation for the unusual polymathy exhibited by Nobel laureates may stem from what has been called the “novice effect.” We have previously observed (R. Root-Bernstein, 1989, 419; Root-Bernstein & Root-Bernstein, 2011, 51–52) that creative individuals tend to produce their most innovative works within a decade of professionally engaging in a field. Moreover, those individuals who continuously change fields or expand the breadth of their endeavors into new ones are much more likely to be continuously creative over their lifetimes than those who remain within the discipline in which they were first trained (R. Root-Bernstein et al., 1993). Polymathic individuals who repeatedly take on the role of beginner or “amateur” by exploring new disciplines, even new domains, renew their chances of ongoing creative contribution.

Some Nobel Prize winners have explicitly adopted this strategy. Tagore, for one, embraced the role of serial amateur, insisting that his visual art, for which he drew much recognition in later life, sprang from “untutored

fingers and untrained mind” (cited in Dutta & Robinson, 1995, 288). More to the point, it was the very “strangeness born of my utter inexperience . . .” that revitalized his creative energies and set the stage for the originality of his expression in visual arts (ibid.). For Ronald Coase “amateurism” – to wit, his lack of formal training in economics – proved a similar intellectual boon: “I had never been trained what to think and therefore what not to think, and this gave me a lot of freedom in dealing with economic questions” (Hirsch & Breit, 2009, 193). Allais, too, was self-taught in economics. Calling himself a “passionate amateur” (cited in McCarty, 2001, 175), he made throughout his multiple careers “a long and often laborious effort . . . to detach myself from the established tracks and dominant ideas of my time” in order to question the gaps between received theory and observed reality (Allais, 1989, 6).

Among Nobel scientists, Robert Holley [Med 1968] once described himself as a “pioneer” who changed fields every five or ten years. His *modus operandi* was to open a new frontier in biomedical sciences, perform enough research to attract other scientists to the area, and then, as soon as there were more than two or three other groups dedicated to the research, move on. Luis Alvarez [Physics 1968] did something much the same. When he found himself, after his Nobel Prize, in mid-career and out of touch with the latest developments in physics, he abandoned his area of expertise and apprenticed himself to a pair of graduate students to learn about newly emerging problems (Alvarez, 1987). William Moerner [Chemistry 2014] said of himself: “I am a perpetual student, always wanting to learn new fields.” He advocated depth of focus in one science, coupled with broad understanding “on the side” of others. “Most exciting discoveries,” he argued, “are appearing at the interfaces between fields” (Moerner, 2015, n.p.). Eric Betzig, a physicist who won the chemistry prize along with Moerner, has similarly and deliberately alternated periods of focus with periods of search for inspiration in other disciplines:

In my personal experience it has been valuable at certain times of my life to seek out information and ideas across disciplines, and at other times to focus monomaniacally in isolation on a single problem. The former is necessary to make sure I choose the right problem and have the right tools at my disposal, and the latter is necessary to force both my conscious and subconscious mind to give 100% to finding an answer. (cited in Rehman, 2015, n.p.)

Steven Chu [Physics 1997] remarked in similar vein that “I have been a scattered dilettante for my entire life” (Rehman, 2015, n.p.).

In these and other similar remarks, many laureates have recognized the need for revitalization from beyond their zones of comfort and expertise.

Polymathy as recreation leading to re-creation

Finally, and perhaps most obviously, wide-ranging interests, especially when they include avocational endeavor, may function as release from the stresses of work. Churchill, whose polymathic perspective serves as epigraph to this paper, was eloquent on the “first importance” of a hobby – or two or three (1950, 8). Best known as a politician, he in fact made the bulk of his living from writing. Around the age of forty, he began to paint for pleasure, eventually producing hundreds of paintings, and at a level of achievement high enough to participate in numerous exhibitions (many of them anonymously). Hallmark Cards Inc. even reproduced sixteen of his paintings on greeting cards (Alkon, 2006, 97; Taylor, 1954, 383–384). In *Painting as Pastime* (1950), Churchill argued explicitly for the contemplative benefits of intellectually challenging avocation.

Churchill’s rationale for avocational activity has been shared by other laureates, either as a necessary relaxation from work, as an additional outlet for personal fulfillment, or both. Economics laureate Engle had what amounts to a separate career as an ice dancer who once studied with Torvill and Dean. He placed several times in the late 1990s in professional ice dancing competitions and, as of 2012, was the over-50 age group national champion (Kiderra, 2012). “When I am skating,” he has observed, “economics is far away. I always return refreshed and ready to carry on” (NobelPrize.org, 2003). Indeed, the avocation was an important “balance” to his research job; multiple activities worked “to keep you from getting too stressed out in any one field” (AQR, 2016, 13). Fellow laureate Douglass North also “complemented” and “enriched” his scholarly research with a variety of activities; as did Eric Maskin, for whom music performance “allow[ed] for a particular kind of self-expression that you don’t really have scope for when you are writing [impersonal] papers . . .” (NobelPrize.org, 2014b).

Among science laureates, Frederick Banting [Med, 1922] also valued his painting as recreation. He regularly took time out from his diabetes research in the 1920s to paint the Canadian wilderness with Alex Jackson, one of the famous Group of Seven. Referring to these expeditions, Banting wrote that, some people “on account of high life are wrecked, while others who go for recreation are re-created” – he himself was one of the latter (1979, 36). The arts had a similarly tonic effect on Wilhelm Ostwald [Chemistry 1909]. Even amid

of his most important scientific work, he would take a break to refresh his mind through painting and music (Walden, 1904, 101). In 1903 he told an American audience, “I personally am indebted to art for many uplifting and beautiful hours. Poetry, music and painting have given me refreshment and new courage, when exhausted by scientific work I have been obliged to lay my tools aside” (Ostwald, 1903, 18; see also 1905, 16). Roger Sperry [Med 1981] more simply called his forays into painting “anti-brain strain” activities (R. Root-Bernstein, 2005).

For some laureates, recreation seems to have had direct connection to professional creativity (R. Root-Bernstein et al., 1993). Just as Hesse found that relaxing with painting stimulated his writing, Einstein found that music enabled him to get around problems he could not solve by a direct attack. His son Hans Einstein recounted that “whenever he [Einstein] felt that he had come to the end of the road or into a difficult situation in his work, he would take refuge in music, and that would usually resolve all his difficulties” (cited in Clark, 1971, 106; see also Maja Einstein, cited in Sayen, 1985, 26). Indeed, Platt and Baker (1931) and Root-Bernstein et al. (1993) have found that half of all scientific insights occur outside of work, many during leisure-time activities. The notion that relaxation somehow allows the mind to get out of the blind alleys into which reason has led it, or to process information in informal yet productive ways, seems to have some validity. Davis, Davis, and Hoisl (2013) further found that patented inventions developed during leisure time turned out to be more valuable in terms of subsequent licensing rights than patented inventions developed during work time. And Eschleman, Madsen, Alarcon, and Barelka (2014) documented across many disciplines that those employees who made “recovery time” a regular part of their work week (often by means of arts, crafts, and music-related avocations and hobbies) had higher work performance evaluations than those who did not.

In addition to “recovery time,” multiple interests appear to affect professional work by providing an alternate or risk-free space, as it were, for serendipitous thinking. Economist McFadden pursued farming as his “main avocation, almost a second vocation” (NobelPrize.org, 2000b), apparently for similar reasons. Working his small farm and vineyard in Napa Valley, he found, “clears the mind, and the vineyard is a great place to prove theorems” (ibid.). Similarly, Kroto was willing to take extraordinary intellectual risks in his chemistry research because he had graphic design as a fallback vocation.

As anecdotes, Einstein solving physics problems at the piano and McFadden proving theorems in the vineyard reiterate the point that for many if not most Nobel laureates work and play are not separate, but closely intertwined. Outside this and other elite groups, however, such integration is unusual. R. Root-Bernstein et al. (1993) found that among scientists, those with average or below-average publication and impact records almost always described their avocations as distractions that took energy away from their work. In contrast, those who had earned Nobel Prizes or were members of the U. S. National Academy of Sciences almost universally described time spent on avocations as a means of increasing work efficiency and effectiveness. Similarly, Berlow et al. (2021) report that the most common profile among the general population is the risk-averse monotasker who focuses creative efforts on one thing to the exclusion of everything else. Given that the integrative, multidisciplinary, networked polymathic profile that is the most common among Nobel laureates is the rarest of the seven creative profiles documented in the Berlow, et al. study, we may say with confidence that most Nobel Prize winners differ from average professionals by specializing in breadth.

Conclusion

To summarize, previous statistical study has found that polymathic networks of vocational and avocational interest predominate among Nobel Prize winners and discriminate them from their less-successful peers. Here we confirm using qualitative and phenomenological data that this multidisciplinaryity is generally a considered choice. Peers often recognize Nobel laureates as being rare, polymathic or “Renaissance” people; Nobel Prize committees often award their prizes explicitly for transdisciplinarity and integration; and Nobel laureates themselves often describe their polymathic pursuits as conscious strategies to optimize their creative potential.

The question naturally arises as to whether the multidisciplinary tendencies and choices of so many Nobel laureates are the result of innate personality or other, contingent factors. Certainly, a robust literature exists linking creativity to “openness to experience,” one of the so-called “Big Five” traits used by psychologists to categorize personality types (Feist, 1998; Kaufman & Gregoire, 2015; Runco, 2007; Simonton, 2017). To the extent that polymathy entails a responsiveness to multiple ways of learning and understanding the world, one might posit that the polymath is particularly open or sensitive to, or otherwise driven to explore, a wider range of psychic, symbolic, intellectual, and social

experiences than more narrowly trained or focused individuals. At present, however, we urge caution in accepting this conjecture as an exclusive conclusion. We are unaware of – and this study does not provide – any data relevant to personality measures for the Nobel laureate cohort. Indeed, given the line of investigation undertaken here, it seems equally plausible that polymathy is a learned behavior or a formal creative strategy adopted in response to the nature of the scientific, artistic, economic, or social challenge addressed.

Indeed, the ability of Nobel laureates to develop their polymathic interests and harness them to creative ends is probably the result of a confluence of factors. These include (on average) a greater access to educational opportunities and a higher-than-average regard for learning associated with their family's values. They also include considered decisions to train differently and more broadly than their peers; to constantly retrain and extend themselves as amateurs and novices; and to develop highly integrated networks of transdisciplinary enterprise that meld vocational and avocational sets of skills and knowledge. While openness to experience may play a role in stimulating such behaviors, it cannot explain the specific strategies that laureates have employed in exploiting their unusual educational choices. In turn, these choices enable them to perceive unusual opportunities at the intersections of disciplines or in themes that run across them and to purposefully use their specialization in breadth to transfer ideas and techniques from one field to another or to integrate knowledge across domains.

If the polymathy of Nobel Prize winners is not an underlying cause of their creativity, it is certainly perceived by colleagues, Nobel Prize committees, and the laureates themselves to be a significant factor contributing to their productivity, one that many attempt to manipulate towards specific creative ends. This purposefulness suggests that polymathy is more than a mere character trait or a statistical correlate of success. It is, rather, a personal and educational choice that might be fostered or emulated by society at large as a powerful creative strategy.

Over the past century scholars have confirmed in many ways and with diverse populations that creative eminence closely associates with versatile abilities across multiple fields of interest (reviewed in Root-Bernstein & Root-Bernstein, 2020a). Some of these studies have focused, as the present one does, on people of the highest attainments in their fields. Cox (1926), White (1931), Hutchinson (1959), and Simonton and Cassandro (2010), among others, all found that creative “geniuses” across many disciplines were significantly more likely to have mastered a wider range of disciplines than the

average college graduate. Similarly, in a study of MacArthur Fellows, contemporary recipients of the so-called “genius awards,” Root-Bernstein and Root-Bernstein (2006) found a higher-than-expected incidence of imaginary world invention both in childhood play and in adult work. As a self-choice activity sustained over many months or years, such worldplay necessarily involves transdisciplinary learning and practice.

Talented individuals of less august creative practice appear to share some of the same polymathic tendencies. In a full-length study of imaginary world invention among the anonymous many as well as the famous few, M. Root-Bernstein (2014, 2021) demonstrated that that complex play, even in less elaborate forms, can promote creative competence in diverse accomplishment across the lifespan. Likewise, Milgram and colleagues found that having a long-term, intellectually intense avocation was a better predictor of success in any career than IQ, grades, or standardized test scores (Milgram & Hong, 1993; Milgram, Hong, Shavit, & Peled, 1997). Selznick and Mayhew (2018) found that double majors were more likely to become entrepreneurs. Pitt and Tepper (2012) reported increases in a variety of creative behaviors and outcomes for double majors as compared with single majors, especially when double majors span disparate domains of knowledge such as science and art (Pitt & Tepper, 2012). Along the same lines, R. Root-Bernstein and collaborators have demonstrated significant correlations between success as a scientist or inventor and arts and crafts avocations (whether as children or adolescents or as adults) for members of the National Academy of Engineering, engineering faculty at Michigan universities, and scientists at a variety of American universities (LaMore et al., 2013; Root-Bernstein, Root-Bernstein et al., 2013; Root-Bernstein, Van Dyke, Peruski, & Root-Bernstein, 2019; Root-Bernstein et al., 2019).

Polymathy, it would appear, can predict creative success at diverse levels of learning and engagement. In general, however, it remains the case that elite groups sustain higher levels of polymathy than groups of less elite peers. Nobel laureates in the sciences, as well as members of the U.S. National Academy of Sciences and members of the U.K. Royal Society, are much more likely to pursue multiple interests than average scientists (Root-Bernstein, et al., 2008). Commensurate levels of multidisciplinary characterize Nobel Prize winners in literature, economics, and peace as well, variously distinguishing them from general publics in Europe, Japan, and the U.S. (Root-Bernstein & Root-Bernstein, 2020b).

In addition, we have observed elsewhere that innovative individuals with multiple areas of interest and endeavor are most likely to make multiple significant breakthroughs across their lifetime, primarily by shifting disciplines and even domains (R. Root-Bernstein, 1989; R. Root-Bernstein et al., 1993; Root-Bernstein & Root-Bernstein, 2011, 52). This broad observation would appear to make moot the debate between domain specific or domain general creativity, such as to be found in Sternberg, Grigorenko, and Singer's edited volume of essays (2004). Creative polymaths, and among them the many Nobel Prize winners studied here, have availed themselves of both, exploiting depth of interest in breadth of practice. They have engaged general creative practice across multiple vocations and/or avocations to address specific disciplinary problems in new and fruitful ways. In many cases they have either created new disciplines or integrated old ones, blurring or obliterating existing domain boundaries in the process.

In sum, the multidisciplinary is a type of specialist who masters not one knowledge domain but a well-defined set of problems, principles, skills, and methods that transcend and link multiple domains. Specializing in breadth can be a path to innovation at least comparable to, and (at least in terms of numerous Nobel Prizes) arguably better than, disciplinary specialization alone.

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