**Two Roads Diverge in a Wood: Indifference to the Difference Between ‘Diversity’ and ‘Heterogeneity’ Should Be Resisted on Epistemic and Moral Grounds**

Anat Kolumbus\*, Ayelet Shavit\* and Aaron M. Ellison

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Two roads diverged in a wood, and I—

I took the one less traveled by,

And that has made all the difference

from *The Road Not Taken*, by Robert Frost (1916)

**Abstract:**

We argue that a conceptual tension exists between “diversity” and “heterogeneity” and that glossing over their differences has practical, moral, and epistemic costs. We examine how these terms are used in ecology and the social sciences; articulate a deeper linguistic intuition; and test it with the *Corpus of Contemporary American English (COCA)*. The results reveal that ‘diversity’ and ‘heterogeneity’ have conflicting rather than interchangeable meanings: heterogeneity implies a *collective* entitythat *interactively integrates* differententities, whereas diversity implies *divergence*, not integration. Consequently, striving for diversity alone may increase social injustice and reduce epistemic outcomes of academic institutions and governance structures.

\* Equal main contributors.

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**1. Introduction: Diversity in the Ecological and Social Sciences**

The concepts of diversity and heterogeneity are two basic types of dissimilarity that are implicitly and commonly assumed to hold interchangeable meanings by scholars and laymen alike. However, when we examined their actual usage, a surprising conceptual discrepancy – in fact a tension – emerged. In this article we call attention to this tension between ‘diversity’ and ‘heterogeneity’[[1]](#footnote-1) and we argue that there are non-trivial epistemic, moral, and practical costs to science and society when this difference is glossed over.

Our critical examination is part of a large body of literature on the benefits of diversity for science and society. There exist strong epistemic (Shrader-Frechette 2002; Longino 2002; Solomon 2006b) and moral (Haraway 1979; Fricker 2007; Douglas 2009, 2015) arguments for diversity in institutions, governance structures, and ecological systems (“ecosystems”). For example, empirical evidence shows that diversity improves academic performance (Gurin et al. 2004; Freeman and Huang 2015; Page 2014), because diverse individuals hold different values (Longino 1990; Harding 1991), situated knowledge (Haraway 1989), socio-gender locations (Code 2006), research styles and specialities (Gerson 2013) and conflicting theoretical scaffolds (Wimsatt and Griesemer 2007). There also are costs associated with diversity, including feelings of isolation and alienation leading to reduced academic achievements of minorities (Armor 1972; Holoien 2013) and unbridgeable disagreements among researchers that disintegrate research groups (Gerson 2013; Shavit and Silver, accepted for publication).

There also are societal costs of divergence between scientists and non-scientists. Within the social realm, increased divergence from scientific worldviews may facilitate public manipulation by spreading ignorance – agnotology (Proctor and Schiebinger 2008) – and untrue and/or unjust environmental outcomes (Shrader-Frechette 2002). Within the scientific realm, divergence exempts scientists from responsibility for not assessing carefully enough social risks of generalizing their recommendations outside the laboratory, field, or model (Douglas 2009). Given the increasing science-society divergence, it is often non-experts who engage with the public – e.g., journalists teaching politicians about climate change or students teaching the underprivileged – which further widen the separation and may also silence local knowledge (Fricker 2007), e.g. by leading experienced mothers not to consider their comprehensive understanding and information as ‘knowledge’ compared to a young psychology student who never held a child, or depriving those living all their life near a spring to “know” their local flow rate compared to an ecology student or governmental regulator who read published results taken at random from nearby streams (Shavit, Kolumbus and Silver, accepted for publication).

Given the fine line between the costs and benefits of constructive and destructive dissimilarities, interrogating the most basic concepts and measurements of dissimilarity seems important and timely. This paper aims for a step in that direction.

**2. Definitions of Dissimilarity**

Fundamental to both diversity and heterogeneity is the concept of “variance” (Fisher 1918, 1925). Briefly, measurable properties (“variables”) of a group of individual entities (a “population” of cells, organisms etc.) are rarely identical. Rather, they will take on a range of values ***y*** = {*y*1*, y*2*, y*3, … *yn*}, where the value of the variable measured for the *i*th individual is denoted *yi*. When graphed as a histogram (Tukey 1977), these values are distributed, with the most frequent values clustered around the most common one and rarer values towards the edges.

The average value of the distribution of the measured variables (its expected value *E*(***y***) or its mean value $\overbar{y}$), equals the sum of all the individual measurements divided by the number of individuals, *n*: $\overbar{y}=\sum\_{i=1}^{i=n}\frac{y\_{i}}{n}$. The variance, or “spread” of the distribution is the sum of the squared differences between each individual measurement and the mean: $σ^{2}=\sum\_{i=1}^{i=n}(y\_{i}-\overbar{y})^{2}$. The standard error of the mean $(\frac{\sqrt{σ}^{2}}{n})$ provides intuitive estimates of how variable the set of measurements is. Under reasonable assumptions, ≈63% of the measurements fall within ± 1 standard error of the mean, and ≈95% fall within ± 2 standard errors of the mean.[[2]](#footnote-2)

In statistics (and hence in nearly all the social and natural sciences), means and variances are characteristics of single populations (groups of measurements), but heterogeneity usually is a composite property of a group of measurements taken from more than one population. For example, the classic analysis of variance (ANOVA) developed by Fisher (1918) is used to determine if two or more populations differ in their average measured traits (e.g., height). A basic assumption of ANOVA is that the variances of the populations being compared are equal; this is referred to as “homogeneity of variance” or “homoskedasticity”. In contrast, if variances are unequal (heterogeneous or heteroskedastic), mathematical transformations of the data must be done to ensure that variances are homogeneousprior to comparing populations using ANOVA.[[3]](#footnote-3) Note that ‘heterogeneity’ here describes only the variance as a problem to overcome in order to allow a *common basis* for comparison. Throughout the rest of this article, however, the concept of heterogeneity describes entities within a collective. “Diversity”, if it is used at all in statistics, refers simply to describe a collection of datasets that describe a wide range of different, often incommensurate, variables.

In contrast, diversity is used widely in ecology (e.g., McGill et al. 2015) and the social sciences (e.g.,Page 2011). Unlike variance or heterogeneity, diversity is not a simple, one-dimensional predicate. McGill et al*.* identified at least 15 different kinds of ecological diversity; differences among them reflect the number of variables or populations that are measured (one or more), the spatial scale of measurement (local or regional), and whether it is measured within or between populations. Unlike ‘variance’ or ‘heterogeneity’ – both of which are interpretable on their own – ‘diversity’ has little meaning to an ecologist unless it is associated with an object. For example, the concept of *alpha* diversity refers to the number of different species in a locality, the concept of *gamma* diversity to the number of different species in a region [a collection of localities], and *beta* diversity measures population change between localities.[[4]](#footnote-4)

In the social sciences, Page (2011) makes similar distinctions between three kinds of diversity: (1) *variation*, or diversity within a type, referring to quantitative differences in a specific variable; (2) *diversity of types*, referring to qualitative differences between types; and (3) *diversity of composition,* or the way types are arranged. Page’s variation is directly analogous to an ecologist’s alpha diversity, and his diversity of types and diversity of composition are analogous to different dimensions of an ecologist’s beta diversity. Most social scientists use “diversity” as a catchall phrase not attached to any particular measured process (Page, personal communication), but we suggest that more attention should be paid to the dimensions of beta diversity.

Although ‘diversity’ appears to be used abstractly in common parlance and is implicitly assumed to mean something very similar to ‘heterogeneity’, when we examined deeply rooted linguistic intuitions of certain core examples, and tested these intuitions in large databases of linguistic usage, an interesting distinction between ‘diversity’ and ‘heterogeneity’ was revealed, with relevance for understanding and improving civil society and its institutions.

**3. A Conceptual Tension Between Diversity and Heterogeneity**

Whereas scientific language may seem indecisive or vague, artistic language can be precise and revealing. For example, Robert Frost’s *The Road Not Taken* beautifully highlights diverging dimensions of a difference (i.e., ‘diversity’), whereas the etymology of ‘heterogeneous’ implies something quite the opposite: an integration of multiple other (Gr.: *hetero*) kinds (Gr. *genus*) within a single whole.

We argue that attributing heterogeneity to something (e.g., a cell, computer, etc.) implies attributing an *integration* of mutual interactions among different entities that all belong to the same *collective*, whereas attributing diversity to a collection of objects or entities entails neither interactions nor a common collective.

An examination of English idiomatic constructions reveals clear distinctions in usage of diversity and heterogeneity. We would say that the parts of a cell or a clock are heterogeneous, but not that they are diverse. In contrast, we recognize a diverse collection of wall decorations or tools. There is an apparent semantic distinction here: cells and clocks are collectives whose functioning entails the integration of a number of interacting parts, whereas walls or garages function independently of the collection of items hanging on them. In other aspects of common usage, however, many objects in daily speech, including communities, populations, or universities, are called diverse or heterogeneous interchangeably.

The *Corpus of Contemporary American English* (henceforth: COCA; Davies 2008) provides a resource with which to examine common usage of diversity and heterogeneity in more detail. COCA contains more than 520 million words of texts, including scholarly writing, fiction and nonfiction, newspapers and spoken recordings, and has tools to conduct complex searches for occurrences of words, phrases, parts of speech, other linguistic forms, and any combination thereof. Compilations of lists of co-occurrences (i.e.,all types of words [adjectives, verbs, nouns, etc.] or specific words that appear near a target word) that can be used to infer intended meanings of predicates such as diverse or heterogeneous.

Sabar (2016) used COCA to infer motivations underlying regular co-occurrences of words. By identifying partial intersection of words that regularly co-occur more than expected by chance alone, Sabar identified *communicative strategies*: the choices of specific linguistic forms that best contribute to their intended message (e.g., “look” and “carefully” form the phrase “look carefully” that calls for visual attention). Thus, the generality of a communicative strategy that is evident in a particular example is established via a quantitative prediction of a non-random co-occurrence (“look” and “carefully” occur together and in sequence more frequently than expected by chance alone, and Sabar (2016) confirmed that “look” and “see” differ in meaning as a feature of attention by showing that “look” co-occurred more frequently with words such as “notice” than did “see”).

 We searched COCA and the *Wikipedia Corpus* (Davies 2015) for frequencies of “diverse” and “heterogeneous” and tested our hypotheses regarding differences in meaning between them using chi-square tests for non-random frequencies. “Diverse” occurred 12-30 times more frequently than “heterogeneous” in the corpora. In line with our hypothesis, “homogeneous”, “collective”, “whole”, “integration” and “interaction” co-occurred significantly more frequently with “heterogeneous” than with “diverse” (improved prediction by, respectively, 58, 24, 8, 11, and 11%). Antonyms of these words (“single”, “individuals”, “division”, “separation”) showed only random patterns of co-occurrence when they co-occurred at all (see tables 1-7 in the Appendix). A possible explanation for the latter findings is that while concepts of a collective whole seem to be more explicitly related to ‘heterogeneity’, words and meanings of singularity are relevant to both terms (in the case of heterogeneity they could relate both a single whole or to its parts). Nonetheless, it is evident that there is empirical support for our semantic intuition regarding ‘heterogeneity’ as interactions among diverse entities within a collective whole, and, perhaps more importantly, the empirical lack of a collectivist meaning for ‘diversity’.

The attribute of diversity does not correctly describe collective entities because its meaning and reference are much wider than the concept of heterogeneity. A heterogeneous entity may be composed physically of nothing more than diverse entities, but as a collective, it entails multiple direct and indirect interactions, and feedbacks, among these entities. All reproducing biological groups (genomes, cells, metapopulations, etc.) are heterogeneous in the collective sense. Hence, additional information that refers to internal interactive processes improves models of heterogeneous entities and systems (Wade 1978; Roughgarden, accepted for publication). Some human groups – e.g., families, football teams or kibbutzim – would best be described as heterogeneous, whereas others – e.g., people waiting to pay the cashier – would not (Shavit 2008). There may be grave costs associated with failing to identify the goals of certain human groups as diverse or heterogeneous, as the next section portrays.

**4. Illustrating the Diversity-Heterogeneity Trade-Off**

*4.1 Moral costs*

Many – perhaps most – readers of this essay would say that promoting diversity is a social good because it is a stepping-stone to heterogeneity and thus to social justice. Although we may not yet have achieved a just and heterogeneous society, we should nonetheless promote diversity as much as possible and not dwell on the semantic particularities of distinguishing the concepts of diversity from heterogeneity. We think this line of thinking is misleading, and that the continuous focus on racial, ethnic, or gender ‘alpha diversity’ (i.e., headcounts) and use of the results of these measurements as a sufficient basis for discourse and policy, creates a vicious circle that may hinder social change in many of our institutions, in particular in our schools, colleges, and universities.

For example, in *Brown v. Board of Education* (1954), the Supreme Court of the United States ruled that segregation of African-American and Caucasian students in schools violated the Equal Protection Clause of the U.S. Constitution. One outcome of this decision was transporting students of different racial backgrounds into different school districts (“busing”) to achieve diverse, “integrated” schools. This was intended to provide equal opportunities, academic aspirations, and achievements for all students and to improve relations among different races (Armor 1972). Unfortunately, according to some of its strongest supporters, busing did not improve academic aspirations or achievements (St. John 1975), sometimes decreased them and often worsened interracial relations: “integration … enhances ideologies that promote racial segregation, and reduces opportunities for actual contact between the races.” (Armor 1972, 13).

In higher education, diversification is primarily done through “affirmative action”. Many scholars support affirmative action (e.g., Bowen and Bok 2000; Rothstein and Yoon 2008), but others have argued that it leads to similar or worse outcomes than would have occurred in its absence (e.g.,Sander 2004; Sander and Taylor Jr. 2012). For example, between 1988 and 2007, faculty of color made up only 17% of total full-time faculty, and that there had been little change in this number since the 1980’s (Turner, González, and Wood 2008). Similar findings have been reported for the number of earned PhDs (NSF 2013).

However one thinks about affirmative action, we suggest that in the interest of promoting social justice that institutions should not measure diversity alone – how many people of different backgrounds are found at a certain time and place – nor wait for it “to work its magic” and reduce injustice. Smith (2015) identifies three problems with current mechanisms for promoting diversity in higher education: (1) responding to calls to improve diversity reactively rather than proactively, often by producing an internal quantified response to an external standardized requirement; (2) failure to include people from the many interacting parts of a university – faculty, staff, students, etc. – in discussions about diversity; and (3) making diversification into a specific program rather than an integral institutional function and goal. All of these common methods of “working towards diversity” are problematic precisely because they increase diversity but reduce heterogeneity. They track and magnify difference and divergence rather than encourage and enhance mutual interaction among all different co-occurring identity groups.

A more positive approach was reported by Walton and Cohen (2011), who conducted a very brief intervention in one’s sense of social belonging (SOB) to a selective, largely Caucasian, college. After three years, there was a significant increase in the GPA (grade point average) of African-American students relative to control groups. SOB is central to a heterogeneous community as it is a psychological aspect of being a part of an integrated collective.

We suggest that a trade-off exists between tracking diversity and building heterogeneity, which may result in a vicious circle leading to blaming those afflicted with social inequality for their under-representation. Since we are better at measuring discrete variables such as grades and gender than at measuring interactions such as SOB and research cooperation, we invest more effort in creating changes we can easily track rather than those that demand more complex, “beta type”, measurements (e.g.,institutional SOB, type of contacts with colleagues or task composition in the lab). As a result of neither measuring these latter dynamics nor investing in their visible change, alienation and lower academic achievements may persist among minority students and scholars (Syed, Azmitia, and Cooper 2011) even while their “diversity” increases. If this processes continues, a dangerous positive feedback may emerge, where not only will one’s self-image and achievements be worsened, but also his/her social identity comes out worse than before affirmative action took place.

*4.2. Epistemic Benefits*

Aiming for heterogeneity rather than diversity often has epistemic benefits. Human collectives – as well as individual agents – have a variety of epistemic perspectives (Shavit, Kolumbus and Silver, accepted for publication). These perspectives differ in multiple inter-related ways, involve different backgrounds and experiences, and vary in ways of perceiving, explaining, and evaluating information about the world. Perspectives direct our attention to track a wide range of phenomena, promote diverse models to explain them (Griesemer 2014) and encourage adaptive-reflection by employing “…a variety of social perspectives, often…by taking the perspective of others” (Bohman 2006, 180).

Information is distributed asymmetrically between agents, so that some of it is known in general, some exclusive to certain groups, and some idiosyncratic to specific individuals (Sunstein 2003; Andesron 2006; Solomon 2006a; Gerson 2013); lack of interaction keeps pieces of information latent.[[5]](#footnote-5) Diversity alone will not ensure that information is shared and provides fewer opportunities for agents to reflect on information that they can access only through interactions with others (Longino 2002; Tollefsen 2006).

Integrative working interaction across specialties – unlike the typical diverse-one-way adoption of ideas from one disciplinary to another – “includes coordinated efforts to pose and solve new research problems that can redefine specialty boundaries” (Gerson 2013, 516), and leads to developing new specialties. Tollefsen (2006) interweaves individual and collective knowledge in a way that demonstrates the benefits of epistemic heterogeneity. She suggested a framework of splitting a group that shares a common goal (e.g., works on a related set task or problems) into sub-groups; heterogeneity is manifested on an inter-sub-group level. Each sub-group is responsible for a different task, has its own sub-goals, and devises its own strategies and solutions. Mutual interactions result when the sub-groups return to the original group setting to present their suggestions and give feedback to other sub-groups. They encounter dissenting perspectives of out-groups and are forced to consider them and examine their own perspective closely. This self-scrutiny and actual encounters with critiques by other groups reveals problems, such as inaccuracies, leaps and gaps, and uncertainties, allowing the sub-groups and the integrated collective opportunities for self-correction (Tollefsen 2006).

Since all sub-groups are part of a larger community that shares a common goal, they both depend on other sub-groups and are depended upon by them. This framework is heterogeneous rather than diverse as the common goal and the inter-sub-group interactions serve to integrate the group. It also maintains differences, thus reducing the danger of group cohesiveness leading to unanimity and conformism, without promoting divergence. Such a framework increases the chances of achieving accurate results and obtaining a more just process of decision-making.

**5. Conclusion**

Diversity is not heterogeneity, and a continued focus on the former is not increasing the latter; instead, there is often a trade-off and tension between them. We illustrated how heterogeneity can better advance academic institutions and governess structures by integrating different people, identities, perspectives, and sources of information; it facilitates interactions among them, which have constructive epistemic and moral implications. Conversely, diversity alone often leads to divergence, is insufficient to resist social injustice and it misses epistemic opportunities that result from integrative working interactions. Institutions are often unaware of the diversity-heterogeneity tension or remain indifferent to it. They invest efforts in promoting diversity while neglecting heterogeneity, thus paying the costs of the trade-off and not reaping its benefits. Tracking alpha and disregarding beta diversity maintain this trade-off and obscures it. For moral and epistemic reasons we suggest noting this conceptual and practical difference and aiming for heterogeneity.

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**Appendix**

**Table 1.** Wikipedia Corpus total target words occurrences.

|  |  |
| --- | --- |
| **Diverse**  | **Heterogeneous** |
| 30967 | 1096 |

**Table 2.** Co-occurrences of “heterogeneous”/ ”diverse” with “interaction”. Hypothesis: “heterogeneous”-“interaction” > “diverse”-“interaction”.

|  |  |  |
| --- | --- | --- |
|  | *Interaction* present | *Interaction* absent |
|  | N | % | N | % |
| Heterogeneous | 11 | 18 | 1085 | 7 |
| Diverse | 49 | 82 | 30918 | 93 |
| Total | 60 | 100 | 32003 | 100 |
| *P*<.001 |  |  |  |  |

**Table 3.** COCA total target words occurrences.

|  |  |
| --- | --- |
| **Diverse**  | **Heterogeneous** |
| 16685  | 1305 |

**Table 4.** Co-occurrences of “heterogeneous”/ ”diverse” with “collective”. Hypothesis: “heterogeneous”- “collective” > “diverse”- “collective”.

|  |  |  |
| --- | --- | --- |
|  | *Collective* present | *Collective* absent |
|  | N | % | N | % |
| Heterogeneous | 5 | 31 | 1300 | 7 |
| Diverse | 11 | 69 | 16674 | 93 |
| Total | 16 | 100 | 17974 | 100 |
| *P*<.001 |  |  |  |  |

**Table 5.** Co-occurrences of “heterogeneous”/ ”diverse” with “whole”. Hypothesis: “heterogeneous”- “whole” > “diverse”- “whole”.

|  |  |  |
| --- | --- | --- |
|  | *Whole* present | *Whole* absent |
|  | N | % | N | % |
| Heterogeneous | 7 | 15 | 1298 | 7 |
| Diverse | 40 | 85 | 16645 | 93 |
| Total | 47 | 100 | 17943 | 100 |
| *P*<.05 |  |  |  |  |

**Table 6.** Co-occurrences of “heterogeneous”/ ”diverse” with “integration”. Hypothesis: “heterogeneous”- “integration” > “diverse”- “integration”.

|  |  |  |
| --- | --- | --- |
|  | *Integration* present | *Integration* absent |
|  | N | % | N | % |
| Heterogeneous | 6 | 18 | 1299 | 7 |
| Diverse | 28 | 82 | 16657 | 93 |
| Total | 34 | 100 | 17956 | 100 |
| *P*<.05 |  |  |  |  |

 **Table 7.** Co-occurrences of “heterogeneous”/ ”diverse” with “single”. Hypothesis: “heterogeneous”- “single” < “diverse”- “single”.

|  |  |  |
| --- | --- | --- |
|  | *Single* present | *Single* absent |
|  | N | % | N | % |
| Diverse | 77 | 97 | 16608 | 93 |
| Heterogeneous | 2 | 3 | 1303 | 7 |
| Total | 79 | 100 | 17911 | 100 |
| *P*>.05 |  |  |  |  |

1. In this article, we use the analytic tradition of concept notation. If quoting the concept’s usage, it will appear as “X” (e.g., Fisher’s “diversity” is defined as…), when explicitly mentioned as a concept it will appear as X (e.g., the concept of diversity is…), and when implicitly mentioned as a concept it will appear as ‘X’ (e.g., ’heterogeneity’ here describes…). [↑](#footnote-ref-1)
2. Ellison and Dennis (2010) provide a full discussion of the assumptions behind these estimates and calculation of associated confidence intervals. [↑](#footnote-ref-2)
3. See Gotelli and Ellison (2012) for details and another example of a “cost” of heterogeneity. [↑](#footnote-ref-3)
4. Each of these can be unweighted (i.e.,simple counts of different species) or weighted by their abundance or sizes (Chao et al. 2014). [↑](#footnote-ref-4)
5. There is an on-going discussion regarding the epistemic efficacy of deliberation, which is beyond the scope of this article. [↑](#footnote-ref-5)