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Annealing as an Alternative Mechanism for Management

Matthew S. Bothner[1]*, Richard Haynes[2]**, Ingo Marquart[3], Hai Anh Vu[4]

[1]ESMT Berlin

[2]CFTC

[3]statworx

[4]University of Economics Ho Chi, Minh City

*matthew.bothner@esmt.org

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Abstract

This paper examines annealing as a mechanism for inducing organizational change. Similar to a sword maker or glassworker transforming physical objects, a manager who anneals strategically shakes up a team with a sudden disruption and, after seeing favorable change, stabilizes the team in a realigned and improved structure. Annealing thus involves "lighting a fire" under colleagues, observing their adaptations, and eventually locking in the gains. Using the work of Harrison C. White as our foundation, we clarify the core features of annealing in contrast to routine management, discussing annealing as a strategic response to uncertainty that temporarily sacrifices equilibrium in search of a better state. Given our interest in when annealing is likely to damage, rather than benefit, those subjected to it, we also identify three conditions under which it fails or is harmful: the annealer lacks robust status, the annealed lacks emotional energy, and the wider environment presents an imbalanced mix of resources and uncertainty. Our discussion offers a window into when and how annealing can revitalize stagnant organizations or cause unintended harm. We conclude with questions for future research.

Keywords

Adaptation, Change, Innovation, Networks, Status, Uncertainty

Introduction

"Annealing is a term from metallurgy. To anneal is to heat and thus shake up the mineral ... more or less at random, and then to cool [so] that the new formation will have more desirable properties" (White, 2008, p. 325). Metal, glass—and people—can be subjected to annealing. In a forge, a sword maker heats up metal to make it flexible and then cools it gradually to reduce brittleness. In a studio, a glassworker warms glass to ease internal stresses, before cooling it into a more durable state. In an organization, a manager strategically shakes up a team with a sudden disruption and, after seeing favorable change, stabilizes the team in a realigned and improved structure (Eccles & Nohria, 1992; Leifer & White, 1986). Annealing thus involves "lighting a fire" under colleagues, observing their adaptations, and eventually locking in the gains.

Inspired by the work and legacy of White (2008), in this paper we address two main questions. First, drawing on the work of White and his collaborators: What are the defining features of annealing in an organizational context? Second, extending White's ideas: Under what conditions (cf. Dubin, 1970; Shipilov et al., 2023; Whetten, 1989) will annealing likely damage, rather than benefit, those subjected to it?

Confronting these questions is important because annealing, while potentially improving overall welfare, also carries substantial risks. On the one hand, it can incite innovation, learning, and needed network change. On the other hand, it can cause the human equivalent of broken swords and shattered glass.

Acute organizational stress can result in extreme, and even tragic, outcomes, such as suicides (Schaefer & Korotov, 2014). To better understand annealing and its varied outcomes, we first clarify its core features, turn next to illustrative examples from business history, and then conclude with scope conditions that limit its effectiveness—or make annealing harmful.

On a personal level, we stress that Harrison C. White's acts of heating and cooling his collaborators resulted in energizing drama, making research unusually engrossing and locking in long-standing loyalties. Our paper is dedicated to White's memory, in deep gratitude for his intellectual leadership and influence on our careers.

Routine Management

One way to grasp the core features of annealing is to view it against the backdrop of what it isn't: standard management. Amidst stability, a standard manager (M) and an annealer (Z) appear similar, but when new uncertainty erupts, M and Z diverge sharply. While Z harnesses uncertainty to "heat" the organization, M works to contain and reduce it, working to preserve normality. We thus offer a stylized picture of a manager M distilled from Kotter's (2001, 2008) work, before drawing further contrasts with an annealer, Z.

Our manager M has a primary directive: maintain reliable order within a complex organization. In the familiar volatility-uncertainty-complexity-ambiguity (VUCA) ensemble, the third piece is central: "Management is about coping with complexity," because in the absence of "good management, complex enterprises tend to become chaotic in ways that threaten their very existence" (Kotter, 2001, p. 86).

M's commitment to preventing chaos differs from other portrayals of effective management, which stress the necessity of change to get things done. According to Wrapp (1984, p. 14, 21; White, 2008, p. 310), "The good manager can function effectively only in an environment of continual change.... Only with many changes in the works can the manager discover new combinations of opportunities and open up new corridors of comparative indifference.... In the day-to-day operation of a going concern, [the manager] finds the milieu to maneuver and conceptualize." M thus differs discernibly from Z, an annealer who is closer to Wrapp's portrayal. Z, unlike M, skillfully channels external turbulence, or occasionally injects chaos into the organization, to prompt innovation.

In privileging stability over innovation, M is also risk-averse: "Managerial processes must be as close as possible to fail-safe and risk free. That means they cannot be dependent on the unusual or hard to obtain. The whole purpose of systems and structures is to help normal people who behave in normal ways to complete routine jobs successfully, day after day. It's not exciting or glamorous. But that's management" (Kotter, 2001, p. 93).

M's risk aversion is both an advantage and a liability at the same time: Failsafe procedures reduce the likelihood of explosive accidents in complex organizations, such as chemical plants and weapons facilities (cf. Perrow, 2014, pp. 146–154), while also blocking the exploratory search made possible through annealing. Since M's overarching goal is to prevent chaos, M's encouragement of normality also means that M seeks to avoid strong emotional upheaval—preferring to shield subordinates from confusion or conflict, and using standard procedures to routinize behaviors and preserve predictability.

Overall, M's day-to-day actions are thus threefold: first, chart a course to a known goal, and marshal the resources to get there; second, craft a corresponding formal organizational structure, and populate it with the right people; third, monitor and problem-solve en route to the goal (Kotter, 2008, p. 4). In each of these moments, M aims to return quickly to "business as usual" after disruptions. More generally, when faced with an uncertain event—for instance, the sudden encroachment (Bothner et al., 2007; Piezunka et al., 2018) of a competitor—M's instinct is to gather data, assign probabilities, and convey a sense of "normalcy," rather than opportunistically amplify the uncertainty.

An Anatomy of Annealing

In contrast, the main task of our annealer, Z, is to harness disorder. Z does this deliberately to create variability in the organization, temporarily sacrificing equilibrium in search of a better state (cf. March, 1991). Among the elements of VUCA, uncertainty, more than complexity, is most central for Z. While M labors to buffer subordinates from uncertainty, Z sees in it an opportunity—and often adds even more emotional "heat" (Collins & McConnell, 2015) to disrupt taken-for-granted patterns. Unless Z is a bully—annealing only to gain dominance (Bothner et al., 2012; cf. Askin et al., 2015, p. 7; Bothner et al., 2022, pp. 119–123) as an end in itself—Z heats the organization to drive it from its current uncertainty into a better future state. Z thus raises the temperature not "for sport," but ultimately for reducing uncertainty and raising overall welfare.

Uncertainty and risk are analytically distinct. Unlike M's world of risk—where M can assign probabilities

of success to various strategic options—Z acts in a domain of uncertainty, where these probabilities defy estimation (Knight, 1921). For instance, M can say that taking the company eastward (vs. westward) has an 80% chance of success and then manage accordingly. Conversely, as Z considers expanding the business into the western or eastern part of the country, the chances of success in each direction are unknown. Nor can Z be sure that the currently considered options are the only ones that warrant attention (Langlois & Cosgel, 1993). Z must further discern whether north versus south also merits a place in the east-versus-west choice set.

When faced with such uncertainty, Z does not play it safe. On purpose, Z injects more uncertainty—into an already-uncertain situation—to disrupt existing routines and thus spur learning and innovation: "Annealing involves actively making a system worse off in an effort to let it right itself" (Leifer & White, 1986, p. 240). In making it "worse off," Z creates emotional tension, forcing those subjected to the heating process to reassess their assumptions. Once the disruption proves revelatory—for instance, once it's clear that taking the company eastward is best—Z cools the system, moving it from uncertainty back toward a domain of risk. Z thus doesn't begin with fixed expectations, but rather, like a sword maker, heats, waits, and watches how things "settle out," as the cooling process ensues (Eccles & Nohria, 1992, p. 200).

In this settled, more predictable state—where Z can finally assign success probabilities to various options—Z's actions begin to resemble those of M. Z approximates M's ideal-typical behavior during these stabilizing intervals—effectively making Z a "dual" ideal-type. M-like behavior is, at least part of the time, indeed necessary for Z to act disruptively since endless annealing would soon drain subordinates' emotional energy and erode Z's status. Z's stabilizing phase lasts until the arrival of new uncertainty raises Z's propensity to anneal again.

Z's guiding philosophy, unlike M's firefighting, is that "starting an occasional fire" is necessary for reanimating the firm, "so that extant patterns of interlocking will dissolve and form anew" (Leifer & White, 1986, p. 240). Z's day-to-day actions, when in annealing mode, thus differ from those of M. Instead of mapping out a path to a known goal, Z creates conditions for goal discovery, often by stirring up emotional energy. Rather than obsessing over formal structure, the organization's "skeleton," Z shocks the informal structure, its "central nervous system" (McEvily et al., 2014), causing new networks to emerge. And unlike M's hands-on approach to monitoring and problem-solving, Z sometimes steps back. Z "buys time for more observation" (Leifer, 1991, p. 68), letting the team find new footing, until the cooling phase—as was evident in the approach of Steve Jobs at Apple, to which we now turn.

Face-to-Face Annealing at Apple

Steve Jobs's approach to team-redirection embodies many of the facets of annealing just described. Like Z, Jobs disrupted his teams in order to re-set them on a better trajectory. When initiating a heating phase, Jobs "forcefully seize[d] the emotional center of attention" by using "negative emotions to begin with; he [got] everyone seething with the same emotion, even if it [was] anger at himself" (Collins, 2020, p. 117). He "often riveted the attention of his work groups by insulting them about the quality of their work, but this was just the initiating emotion that got everyone focused. His emotional assaults turned into attunement as they argued out the details heatedly and at length, until they were together on a new path" (Collins & McConnell, 2015).

Importantly, Jobs's tactics were also much more than playground bullying: "his secret was that he never walked away from [his subordinates]: but always saw the argument through to a shared resolution" (Collins, 2020, p. 118). Jobs's approach was one in which creativity emerged from "affective shift," in which intensely negative affect sharpened the team's focus on problems—after which positive affect eased their synthesis of new ideas made possible by Jobs's initial instigation (Bledow et al., 2013, p. 432, 435).

In addition, by not abandoning those he annealed, Jobs seemed to have found an intermediate level of tie strength and information-sharing (Granovetter, 1973). More abstractly, in an annealing project, overly weak ties—that share too little information—merely mystify and paralyze, while excessively strong ties—that convey too much direction—fail to raise the temperature, leaving the target network unchanged. Jobs's annealing eluded both extremes. He found a balance by inciting conflict when necessary, then relying on trust (in himself and likely within the team) to make conflict exploratory, not draining. Jobs was artful in forcing high-stakes "situations" in which "ties and positions [were] put at risk," but which also yielded "opportunities for transformative agency" (Mische & White, 1998, p. 700, 715).

When it was time to cool, Jobs often took a "long walk with his most important counterpart. Something about the rhythm of a long, unforced walk turns a duel into a duo. What may have been a contentious shouting match hours earlier turns into a step-step-

step, walking together talking, and more often than not arriving at an agreement to work together" (Collins & McConnell, 2015). These walks opened up "neutral buffer zones" that eased "switching" out of high-conflict group dynamics into a more cooperative conversational frame (Mische & White, 1998, p. 708; cf. Fuhse, 2022, pp. 229–230). In that new frame, Jobs and his counterpart began jointly exploiting the novelties thrown into relief during their higher-temperature, more exploratory phase (March, 1991). Annealing thus ultimately involves (at least partial) reconciliation—and so encompasses much more than the matador-like insults with which Jobs began.

Systemwide Annealing at General Electric

Jack Welch, a contemporary of Jobs, subjected his employees at General Electric to an annealing process as well, but differently. Welch's heating and cooling phases lasted longer and targeted a larger population. Unlike Jobs who, much like a matador, provoked his colleagues at close range with "roughly ... 20 minutes of insulting, and hours of heated argument" (Collins, 2020, p. 117), Welch shook up GE's entire organization—and did so over a long time frame.

Since he was taking charge of a multilayered, overly diversified system, whose future competitiveness was in question, annealing was a fitting approach. Annealing "is well suited for ... messy 'multibody' problems ... where no global solution is known, and where incremental improvement techniques stand the risk of getting stuck in a local optimum" (Leifer & White, 1986, p. 238). The tensions inherent in GE's wide-ranging system were difficult to manage: "We needed to expand some businesses while shrinking or selling others. We needed to function as one company, but our diversity demanded different styles" (Welch, 2001, p. 125).

Welch used two main methods to disrupt General Electric: the "#1 or #2" rule and large-scale layoffs. These two complementary interventions together reshaped the system, forcing GE's divisions and employees to adapt or get removed.

First, in the early 1980s, Welch required each of GE's businesses to be "the number one or number two leanest, lowest-cost, worldwide" producer in its market: "Being No. 1 or No. 2 wasn't merely an objective. It was a requirement" (Welch, 2001, p. 106). If a business failed to meet this standard, "the managers had to fix it, sell it, or as a last resort, close it" (Welch, 2005, p. 39). Consistent with White's (2008, p. 325) portrayal of annealing as an "intentional, but indirect" intervention, Welch (2005, p. 169) stressed that the "#1 or #2" rule "was not our *strategy* .... It was a galvanizing mantra to describe how we were going to do business going forward. There would be no more hanging on to uncompetitive businesses for old times' sake."

While energizing, the #1 or #2 mantra was also an occasion for widespread uncertainty, leading to "turmoil, angst, and confusion" (Welch, 2001, p. 121) throughout GE. Welch recognized the emotional toll, noting that although "most agreed to it intellectually," those in mediocre businesses "felt tremendous pressure" to act quickly or else get sold (Welch, 2001, p. 109). In time, the benefits of the mantra were apparent. GE's leaders eventually stopped "sprinkling ... money evenly" over underperforming units "for sentimental or emotional reasons" (Welch, 2005, p. 40) and focused instead on high-potential businesses. Welch's (2005, pp. 169–170) summary view of the "#1 or #2" intervention was that it "was a communication tool to clean up our portfolio, and it really worked."

Second, Welch's radical layoffs, giving him the nickname "Neutron Jack," was also an important part of his annealing process: "Within five years, one of every four people would leave the GE payroll, 118,000 people in all, including 37,000 employees in businesses that were sold. Throughout the company, people were struggling to come to grips with the uncertainty" (Welch, 2001, p. 121). Mirroring the effects of a neutron bomb, the buildings stayed, but people vanished.

In this charged atmosphere, GE employees faced pressure to support Welch's new vision—or exit. An important outgrowth of the neutron phase was an identification of the "keepers," or "right horses" (Welch, 2001, p. 132). Clarity about who fit with the new regime emerged as "resistors" got pushed out. Annealing thus stretched and fractured long-standing networks among GE employees, making it possible to "see clearly who had it and who didn't" (Welch, 2001, p. 132). Decoupled from older, less competitive ties, stayers (or survivors) could then coalesce in new networks consonant with the new, performance-driven culture.

Cooling, at the aggregate level, occurred much later: "Years after launching GE's massive restructuring effort, Welch concluded, 'By mid-1988 the hardware was basically in place. We liked our businesses. Now it was time to focus on the organization's software.' He also acknowledged that his priorities were shifting: 'A company can boost productivity by restructuring, removing bureaucracy and downsizing, but it cannot sustain high productivity without cultural change'" (Bartlett & Wozny, 2004, p. 4).

The new culture Welch aimed to instill was to be performance-driven, emphasizing leadership development, creativity, and hard, market-based incentives (Bartlett & Wozny, 2004, p. 7). This cultural shift was further reinforced by Welch's investment in Crotonville, a center for developing managerial talent. Crotonville both symbolized GE's commitment to the new cultural norms (Welch, 2001, pp. 122–123) and provided a sacred site whose fervent town-meeting-style rituals inspired the internalization of these norms (Berger & Luckmann, 1967).

Looking from the standpoint of Welch, as the annealer, the system stabilized in a better form, although many of the annealed surely felt otherwise. According to Welch: "Like many other large companies in the U.S., Europe, and Japan, GE has had an implicit psychological contract based on perceived lifetime employment. This produced a paternal, feudal, fuzzy kind of loyalty. That kind of loyalty tends to focus people inward. But in today's environment, people's emotional energy must be focused outward on a competitive world .... The new psychological contract, if there is such a thing, is that jobs at GE are the best in the world for people willing to compete" (Bartlett & Wozny, 2004, p. 6).

Welch (2001, p. 128) used memorable rhetoric to describe this new psychological contract: "We'd do everything to give them the skills to have 'lifetime employability,' even if we couldn't guarantee them 'lifetime employment.'" Welch's reframing thus offered a new story (White, 2008, pp. 20–62) for the relationship between GE and its employees, in keeping with the competitive demands of the era. It marked an important moment in the cooling phase, offering a degree of stability. We conjecture that ambiguity in the meaning of "lifetime employability" left the relationship open-ended—keeping open chances for future maneuvering (cf. Leifer, 1988), so that cooling, while often achieved, was never a fixed state.

Scope Conditions

It is easy to imagine how overemphasizing lionized annealers, like Jobs and Welch, could be harmful—for theory development, but also management practice. Their examples, while vivid, risk obscuring the contingencies that may make annealing detrimental in different contexts. Our attention to Jobs and Welch was illustrative, not prescriptive.

Our aim in this section is to clarify conditions under which annealing is likely welfare-reducing. Our picture of these conditions is provisional. We offer a starting point that we hope will lead to more detailed studies of scope conditions in future work. New research is important since the contextual features that shape the success or failure of annealing are not matters of formal design easily seen on an org chart (cf. McEvily et al., 2014). We agree with White (2008, p. 7) that "Context is crucial," and for annealing, as with other control projects, the relevant "context is experienced, rather than designed."

If we envision interactions between (i) a principal (the annealer) and (ii) agents (the annealed) embedded in (iii) an environment, then we see three contextual conditions that, independently or jointly, are sufficient for annealing to fail: the principal lacks robust status (Bothner et al., 2010b); agents lack emotional energy (Collins, 2020; Collins & McConnell, 2015); and the environment presents an imbalanced mix of resources and uncertainty. These conditions naturally affect each other empirically, yet are analytically separable, so we discuss each in turn.

Robust Status

Consider this painful scenario: You and your colleagues work for a boss whom you collectively disrespect, one whose mix of incompetence and unethical behavior has eroded your trust. Suppose also that your boss occupies a fragile, rather than robust, status position (Bothner et al., 2010b; cf. Askin & Bothner, 2016, pp. 221–222). Your boss's standing in your local network of colleagues—and in the wider networks of your organization—is vulnerable, rooted tenuously in the single endorsement of a powerful outsider—the revered, yet aging and out-of-touch, founder of your organization. This is a status position that is "just enough" to lead. Your boss lacks a broad base of social support.

Now, imagine your boss initiating an annealing process, heaping dispiriting pressure onto an already dispiriting management style. In response, you and your colleagues quickly disengage. The fragile sword maker then has no material on which to work. For annealing to proceed, the annealer must have robust status—gained through recognition and esteem from others who are both highly regarded (Bothner et al., 2010a; Podolny & Phillips, 1996) and durably embedded in their own networks. An effective annealer must start from a strong footing in the network of deference relations—a necessary precursor for changing interaction rules (cf. Fuhse & Gondal, 2024, p. 49), especially radically. Very few will submit to a heating process instigated by a boss whose status is at best fragile.

More specifically, robust status on the part of the annealer is essential for two main reasons: It not only

signals credibility (cf. Podolny, 1993) but also affords the social support necessary to start and sustain an effective annealing process.

Signals of credibility are vital for the heating process to go forward. As a disruption that counters convention, annealing can make a weakly situated, non-credible boss seem just as desperate and crazy as Weber's "madman" (Kobayashi, 2010, p. 42). In order to engage, those exposed to an annealing attempt must find its instigator credible at the levels of skill and ethics. Put metaphorically, you (as someone annealed by a boss) must believe your sword will be made more durable, and that your sword won't be stolen. Non-credible (prospective) annealers signal neither a better future state nor a fair allocation of rewards. Their attempts to heat are at best bewildering, and so fail to mobilize.

Robust status also offers necessary support amidst the messiness and surprises of annealing. Our hypothetical, fragilely situated boss, even if successful in catalyzing a heating process, by definition lacks the social capital necessary to sustain that process. Annealing involves temporarily "weakening" a system to make it stronger over the long run. That ephemeral phase of weakness must be protected from the threats of vultures keen on poaching those having second thoughts about the journey. Robust status makes unwanted seductions and defections less likely, enabling the annealer to monopolize the disruption.

Robust status can, however, be quickly lost during a mismanaged heating process, even by a boss who starts in a strong position. "Unintentional" annealing is a potential cause of rapid status loss. White (2008, p. 325, 327) depicted annealing as "intentional," stressing that for a social process to "qualify as annealing there must be evidence [of] intentional agency" on the part of the annealer. Nevertheless, unintentional annealing is empirically possible: a principal may inadvertently initiate a heating phase, doing so mainly to offload externally driven stress on unsuspecting subordinates.

Although annealing typically requires "coupling to another larger population" (White, 2008, p. 326), as when a CEO harnesses fierce external competition to prompt internal change, the coupling between the external environment and the annealer can grow too tight. A CEO could become so infected with the uncertainty pervading the environment that "executive presence" gives way to panic. Seen as indecisive and erratic, the annealer's stock of credibility is suddenly gone (cf. White's (2008) reflections on Kaiser Wilhelm).

Robust status can also erode gradually. This can occur when annealing (as an expression of power) slowly grows addictive to the principal—resulting in too many cycles of heating and cooling, which over time confuse and burn out the agents (cf. Estévez-Mujica & Quintane, 2018). Here, the dynamics of physical and social annealing diverge.

On the one hand, in a laboratory setting, "reversals" of the cooling process are common. According to Leifer and White (1986, p. 238), in "crystal formation ... a system of particles at high temperature can be cooled very slowly, allowing equilibrium configurations to form at each temperature change. At the temperature zone where crystals begin to form, the cooling process can be repeatedly reversed until a satisfactory initial configuration is obtained (which shapes the progressive refinements formed through further cooling). Reversal is key to the annealing process, as it allows one to avoid 'bad' local optimums."

On the other hand, in an organizational setting, repeated reversals can be perceived as acts of cruelty. Consider, for instance, an NCAA football coach who pushes players past their breaking points. Even in a discipline where annealing is taken for granted—collegiate athletes sign up for it, even if its timing catches them off guard—there are norms (as well as physiological limits) that constrain the number of heating cycles per week and across a season. When a coach violates those norms—whether through viciously intense practices or by not allowing sufficient recovery—the likely outcome is not adaptation but emotional and physical exhaustion. Exceeding players' thresholds destroys the informal standing of the coaching staff—making everyone, players and coaches, worse off.

Emotional Energy

Our reference to sports brings us to our second boundary condition: annealing will fail if agents lack what Collins calls "emotional energy." Although Collins (2004, p. 68) defines emotional energy, or "EE," at the individual level as "a feeling of confidence, elation, strength, enthusiasm, and initiative in taking action," his theory is fully social: Unlike the stamina a marathoner develops in solo training, EE is gained (or lost) in "interaction rituals" with others, in networks.

According to Collins (2020, p. 115), "One's life can become a self-reinforcing spiral, either positively or negatively: a chain of successful [interaction rituals] that pump you up, make you feel like a member, that gives you the social habitus and cultural capital circulating in your networks, and which you can confidently play back in your future encounters. Or you can fail to get into the shared rhythm of the

interaction—by lack of things to talk about, lack of emotional attunement, lack of micro-habits that play well in that network—and accordingly you feel drained, alienated, and depressed."

EE in the domain of social annealing thus mirrors the structural integrity of steel or crystal in the context of physical annealing. Its presence or absence determines whether agents can endure without fracturing.

When agents, pre-annealing, are emotionally exhausted—and so lack the "free space" to engage in new, demanding emotional states—they will disengage or protest (cf. Hirschman, 1970) once disruption is introduced. Insufficient emotional attunement, as Collins (2020) envisions it, likewise works against the heating process, raising the risk of a downward cycle of disengagement. In contrast, Steve Jobs's employees, amidst his taunts and insults, still managed to align emotionally, collectively retaining the energy to respond to his challenging expectations (Collins & McConnell, 2015).

Even when EE is present ex-ante, it is a finite resource that can be drawn down too far as annealing unfolds—in line with the risks of overly frequent heating and cooling cycles. The organization then lands in a weakened, more brittle state. In the extreme, if the annealed can somehow rally their remaining resources, they may act mutinously (cf. Pfaff, 2006). In contrast, if negative emotional tension is channeled into constructive ends—rather than suppressed—annealing can restore or even amplify EE, as in Jobs's approach: a common enemy for the team can inspire the growth needed to respond to the challenge of annealing.

More generally, if annealing is to succeed, the principal, like a skilled sword maker or glassmaker, must gauge agents' emotional energy levels before proceeding. Collins and McConnell (2015) propose a triad of facets of EE that a situationally aware principal could monitor: physical and mental vitality, focus, and self-confidence. In practice, this monitoring equates to ongoing "EE temperature checks" by the principal, to ensure agents are not drifting into exhaustion, distraction, or despair—states that, if ignored, can derail the annealing process.

Self-awareness matters also, however. The principal must self-monitor to ensure that the demanding task of addressing uncertainty does not eclipse—or even offer a moral license for ignoring—agents' emotional energy levels, leading to both strategic and moral failures. Self-monitoring also implies the possibility of moderating the intensity of annealing to conserve emotional energy over time. For example, the principal might ameliorate the harshness of the program by modulating the rhetoric (i.e., not persisting in full Jobs-like harangues), or even acting counter-to-form, by rewarding a particularly hardworking team member with a mental health day.

In the ideal, annealing evokes "generative resilience," where agents end up "bouncing forward" after a disruption (Burt & Soda, 2021; Grandori, 2020, p. 495; Shipilov et al., 2023). This ideal implies that EE fluctuates over time and, after well-managed annealing, is even increased. We speculate that many of Jobs' team members and Welch's (surviving) executives had larger stocks of EE after annealing ran its course. However, absent EE, annealing falters or collapses, and both principal and agents get weakened.

Environmental Munificence Mixed with Uncertainty

Our final boundary condition concerns the wider environment—a domain beyond the direct control of the annealer and the annealed, but to which both parties are jointly accountable. It may be the broader organizational context, the external market, or both. This environment is "a store of resources as well as a source of opportunities and constraints, demands and threats" (Scott & Davis, 2016, p. 19). We identify two features that are particularly important for annealing.

First, not all environments offer the tangible resources needed to support annealing (White, 2008, p. 326). Sustained search requires a safety net, just as disruption needs a stable support base. According to Welch (2001, p. 129), "the massive nature of the changes at GE would have been impossible without a strong core of supporters inside the company." GE's board and Welch's confidants and allies made his annealing possible. Moreover, slack resources—such as extra funding and time for experimentation (Bothner et al., 2011; Kanter et al., 1997)—are also essential supports.

Second, not all environments impose the uncertainty necessary to justify the initial heating. "Never waste a crisis" is a familiar political proverb. In the same vein, "Crisis is … a labeling to help make action possible" (White, 2008, p. 300). Uncertainty, as in our earlier distinctions between M and Z, legitimates annealing. In contrast, in a purely risk-based domain, annealing can be coded as arbitrary—as disruption for its own sake. Unless the annealer, in the absence of apparent uncertainty, can frame the disruption as vital—for example, as a needed case of contrarian thinking (Liu, 2021; cf. Ehrig & Schmidt, 2022; Felin & Zenger, 2017)—then environmental resources and

uncertainty must be reasonably balanced. Minimal supporting resources amidst acute uncertainty strips annealing of its foundation, while minimal uncertainty alongside abundant resources leaves annealing without sufficient justification.

Conclusion

Using White's work as our foundation, we examined annealing as an intentional device for breaking inertia and, after profitable exploration, resolving uncertainty. We drew contrasts with Kotter's (2001, 2008) ideal-typical vision of management, stressing the annealer's use of controlled disruption to force variation, before stabilizing around discoveries brought forth at high temperature. Illustrations of annealing at a micro-level by Jobs at Apple, and at a macro-level by Welch at GE, revealed how annealing can both assault emotional attachments to "old certainties" and bring realignment around "new possibilities" (March, 1991).

We also underscored annealing's dangers, showing how harm results if the annealer's status is fragile or the annealed lack emotional energy, or if the environment presents an asymmetric mix of resources and uncertainty. Clarifying these conditions adds to our understanding of when annealing is most likely to benefit or damage. Fragile, desperate annealers, who disrupt exhausted colleagues—and do so in an unfitting environment—necessarily cause harm. We note too that, although distinct conceptually, these dimensions rarely operate alone: robust status offers footing from which to attract and impart emotional energy, and that energy is more likely sustained—even amplified—in an environment that at once supports and calls for annealing; in contrast, a shortfall on any one dimension can undercut the others, raising the risk of unintended harm.

Subsequent research will profit from addressing gaps in our current understanding of annealing. We emphasize two important themes here: the rhetoric of heating and strategies for cooling.

First, new research should consider the main rhetorical tensions that must be managed in the heating phase. Earlier, we stressed the importance of network position and emotion, but language must also matter. At the level of the annealer's language, which mixtures of concreteness and abstractness (Snefjella & Kuperman, 2015) yield the most productive reactions? The rhetoric must be sufficiently clear to drive (otherwise inert) agents into productive motion, while also affording them enough generality to allow for experimentation. Overly concrete language limits exploration, while excessively abstract language perplexes and thus fails to bring forward any new actions.

In parallel, other studies could identify the combinations of challenge versus threat-related messages, in the rhetoric, that are most congenial to novel behavior. In general, a challenge is felt as a growth opportunity, while a threat is felt as a dead-end, with no apparent path for coping (Drach-Zahavy & Erez, 2002, p. 667). Yet, these two states, if strategically sequenced, might jointly eventuate in successful annealing. We thus raise this question for future research: to what extent do annealers gain attention by communicating threat, and then move to challenge? Desperation, followed by steady doses of envisioned opportunity, may well turn out to be the most prevalent communication strategy.

Second, future research should cast new light on cooling: How do we know when to cool? And what should happen then? An (experienced) annealer knows it's time to cool when further heat would yield no new insights. Identifying this turning point is harder in social than in physical annealing. Unlike a sword maker, who can decide the time of the start of cooling by attending to the color, and non-magnetic state (Rajan et al., 2023), of metal at very high temperatures, the organizational context is more subjective. Evidence of nascent burnout, the emergence of new strategic direction, or simply diminishing returns to disruption—these can all serve as indicators. Each indicator may call for a different pace of cooling—rapid routinization in the face of burnout, for instance, or more gradual stabilizing, when a new strategy is slowly coming into view.

Since these indicators rest on different normative foundations, higher-order judgments are necessary: stop rules on heating could be rooted in a Rawlsian focus on the least-well-off agents, economic efficiency, or status-preservation—even if a status-based transition into cooling is self-justified along the lines of preserving the opportunity "to do more good in the future."

It is not enough merely to read the indicators and end the turmoil, however. The annealer must also imbue the network of survivors with the conviction that the upheaval was worth it. Cooling, in most instances, must highlight tangible, individual gains ("You're better and stronger now"), and must also affirm collective identity ("We succeeded together"). Such stories "put an orderly face on the underlying messes" (White, 2008, p. 346) still simmering from the disruption. How this rhetoric might possibly be experienced as influence—and not as manipulation—is an important question for those keen to grasp

how exactly robust status can persist for those who repeatedly anneal.

Yet the "promise" of cooling must not be so binding that it seems permanent and thus fosters complacency. Effective cooling, as we observed in Welch's emphasis on "lifetime employability," requires a story that brings order without hindering future action. Whenever the "future is perceived ... as problematic and unresolved" (Mische & White, 1998, p. 700), a balance must be struck between declaring success, retaining the possibility of future disruption, and preserving the robust status of the annealer.

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