# Brave New Interactions: Performance-Enhancing Drugs for Human-Computer Interaction

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## Abstract
In sports, some athletes resort to performance enhancing drugs to gain an advantage. Similarly, people use pharmaceutical drugs to aid learning, dexterity, or concentration. We look at how such drugs could potentially be used to enhance interactions. We envision that in the future, people might take pills along with their vitamins in the morning to improve how they can interact over the day. In addition to performance boosts this, e.g., could also include improvements in enjoyment or fatigue.

## Author Keywords
Performance-enhancing drugs; boosting performance; augmentation; enhanced interaction

## ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

## Introduction
We currently see widespread use of pharmaceutical drugs for purposes other than treating diseases. Students cramming for their next exam or athletes training for an upcoming race resort to such performance-enhancing substances to gain an advantage. This is currently a controversial issue and generally this behavior is seen quite critically by many. However, this stance is a matter

of perspective and we can imagine changes in morals that make this behavior acceptable or even desirable. In fact, we can see that some performance-enhancing drugs are already widely accepted. Nobody would doubt the integrity of ones performance if one were to extensively consume caffeine, yet caffeine, as well, is a performance-enhancing substance.

This should not be seen as an endorsement or demonization of such practices. Instead, we feel this is an issue that is going to be more significant in the future and think it is worthwhile to have an early discussion on how this could impact the field of human-computer interaction. In medical and educational contexts this topic is already hotly debated, but should usage of performance-enhancing drugs in the future become more acceptable the issue is going to impact many more areas. As human-computer interaction research always has to take into account the user, we should not exclude a future possibility of that user being more malleable than right now.

Here, we present areas where performance-enhancing drugs could improve users and how such changes in users could impact human-computer interaction. Drugs could, e.g., increase endurance (potentially impacting how we investigate task load), concentration, or decrease stress. We hope this can be an opener to a lively debate where both sides—those who oppose any modification of humans and those interested in augmenting the human—can exchange their views on the issue.

## Performance-Enhancing Drug Categories

Drugs are used to boost (1) physical performance, and (2) cognitive performance. Physical performance-enhancing is most commonly associated with competitive sports. While generally regarded as unethical and universally condemned in pretty much all sports, use of performance-enhancing drugs (i.e., doping) is nevertheless not that rare. Especially in endurance sports (e.g., cycling) and in sports requiring raw physical strength (e.g., weightlifting), performance-enhancing drugs can offer a big competitive advantage. This is not a recent development and the earliest official ban on such substances dates back to as early as 1928 [22]. However, doping and its prosecution are a cat-and-mouse game, where the incentives to alter ones body to gain an edge is too strong for any deterrence to have an effect. In fact, some have even argued for officially allowing performance-enhancing drugs in sports in face of the realities [22].

Cognition-enhancing drugs on the other hand are found, e.g., in more academic settings. Low and Gendaszek, for example, surveyed students at a small US college and found that 35.5% of the undergraduates had used amphetamines without having a corresponding prescription [17]. Use was primarily motivated by a desire to boost academic performance.

## Enhancing Interactions via Drugs

Interaction does not come for free. Working on a computer system can impose demands on attention, induce stress, require memorization of a large set of possible inputs and even have physical demands. With extensive computerization of the workplace, most employees today are working in front of screens and are thus impacted by how our interactive systems work. This is not to say that life was stress-free and easy before, but the complexity of modern information systems is certainly larger than many earlier pen-and-paper processes. In this section, we provide an overview of current performance-enhancing drugs' effects that could be beneficial for interactions.

*Concentration*
In many occupations concentration is of the utmost importance, e.g., in an operating room or in an air-traffic control tower. Performing complex tasks is strenuous and even in the healthy the capacity to make active choices is limited [1]. Several drugs are available already that boost attention and focus, such as amphetamine salts (Adderall) or methylphenidate (Ritalin) [9]. Developed to help patients with attention deficit hyperactivity disorder, the same drugs also improve the performance of the healthy.

*Memorization*
Drugs intended for the treatment of Alzheimer's disease such as donepezil (Aricept) [10], brahmi, piracetam (Nootropil), or galantamine (Reminyl) [2] have been shown to somewhat improve memory in healthy individuals as well. While this might be beneficial for a number of tasks (and most likely training as well), there could be a risk of making things we would like to forget harder to forget. In contrast to enhancing memorization, drugs are also being developed to block memories (e.g., for after traumatic events) [11].

*Motivation*
Cakic states that when "overcome by a lack of motivation [...] selegiline (Deprenyl) is for you" [2] and indeed selegiline has shown promise in helping people overcome addictive behavior (e.g., smoking [6]). However, this effect does not necessarily generalize to a universal motivation boost. Such a more general effect was self-reported by some users of Adderall and Ritalin though [14].

*Learning*
As we age, our capability to lean new skills slowly deteriorates. Learning a new language at age 50 is not as easy as at age 5. It has recently been shown that histone-deacetylase inhibitors can help adults reactivate some of those learning capabilities—acquiring the skill of absolute pitch [7].

*Fatigue*
Having to stay awake and perform, e.g., in shift-work or emergency situations can be aided by drugs such as modafinil (Provigil) [18, 25]. While such drugs are designed to help, e.g., narcolepsy patients, they also can support healthy people in working longer than their body would usually support them. This property is also desirable in the military and it thus should not be a surprise that many fighter pilots use such drugs to enhance alertness and performance [8]. In addition to pharmaceuticals, common substances such as caffeine also have an effect on fatigue [24].

*Strength*
Strength-boosting drugs are already widely used in sports today. Particularly anabolic steroids are common and can increase strength by about 5–20% [12]. However, steroids can have strong side-effects and would not be an appropriate substance to use for general usage.

## Issues of Performance-Enhancing Drug Use

Of course, performance enhancing drugs are no wonder elixir with only positive impact. In fact, three issues are regularly brought up (e.g., in [2, 5, 9]) when discussing performance-enhancing drugs, cognition-enhancing ones in particular: safety, fairness, and coercion.

*Safety*
The acceptability of side-effects is closely related to the effects of a drug. It would be unacceptable for a drug against the common cold to cause hallucinations or hair loss. However, we are more generous in what is acceptable in, say, a drug to fight cancer. As performance-enhancing use does not serve a direct medical purpose even mild

side-effects could be deemed too much. While some performance-enhancing drugs are known to be more dangerous—like methylphenidate, which has an increased abuse liability [16]—many *"display minimal adverse effects and in some cases appear to be neuroprotective"* [2]. In general, with non-critical drugs, it should probably be people's choice whether they want to trade certain benefits for certain risks. If risks are in range with other over-the-counter drugs, it would be unreasonable to apply more restrictions.

*Fairness*
When used in competitive settings, such as sports, the issue of fairness often receives the most attention. This is under the assumption that there is a natural even playing field and only the added use of performance-enhancing drugs skews the odds. However, genetics or socioeconomic advantages already give some people an edge. In fact, some drugs such as modafinil show better results in users with lower IQs, conferring the greatest advantage to those that need it the most [23].

*Coercion*
Pressure to perform and an assumption that others might boost their performance with drugs is said to drive people to take them as well. This becomes a bigger issue the more of a boost performance-enhancing drugs provide. For example, we can assume nobody feels a need to drink a lot of coffee to keep up with their fellow students, but a professional cyclist probably feels more pressure when it comes to abuse of banned substances. In an HCI context, coercion would be most likely an issue if employers directly or indirectly forced employees to take certain medication to, e.g., be more focused at work. However, there might be cases where it could be deemed okay for employers to do so. If one were to show that some low-risk medication could improve the performance of, say, air-traffic controllers at their tasks, thus increasing the safety of many, a case could be made for such direct coercion to be alright. Warren et al. have investigated a similar scenario for the case of surgeons [26].

## HCI-Specific Applications of Performance-Enhancing Drugs

When it comes to HCI, the question remains: how would performance-enhancement apply to interactions? Will future interface designers also need to think about supplements for their users to go along with a design? And what kind of enhancement will be possible in the future at all? Here we assume prolonged progress in developing safe and potent performance-enhancers and look at how this could impact interactive systems.

Overall, we do not believe much will change for the majority of interfaces. After all, it is only a small subset of all interactive systems that require high attention and do not allow to design for just ease of use. For example, a media streaming application would probably not be designed with performance-enhanced users in mind.

However, there are interactive systems where this might be more of a concern. As mentioned earlier, many fighter pilots already boost their performance via drugs. We can envision future fighter plane designs to deliberately expect pilots to adapt to more high bandwidth and stressful interaction. Pushing just the machine to the limit might not be enough when the user cannot keep up.

But the military is only the most extreme example. There are also a number of high-pressure civilian jobs where humans have to make fast decisions with high impact results on interactive systems. Telemedicine, air-traffic control, reactor safety, or electronic trading come to mind.

An employer placing a user in front of a Bloomberg Terminal to place trades could desire that individual to be focused longer than possible without enhancement. In fact, that employee herself could wish to do so to gain a competitive edge. Maybe those terminals in the future can be made more powerful by adding even more complexity at a level only to be mastered after enhancement (e.g., via more complicated shortcut structures).

While there certainly can be operational benefits, many benefits might materialize just in the training for a new system. With drugs to aid memorization and skill acquisition, training costs could be lower.

Altering human performance via drugs would call some assumptions interface design currently operates on in doubt. For example, according to Card et al., users can keep $\approx 7$ items in short term memory [3]. It might well be that with some current or future cognition-enhancing drug this estimate would not be appropriate anymore. When evaluating task load (e.g., via NASA-TLX) it might be necessary to collect augmentation level from participants as well. High fatigue in a user regularly taking performance-enhancers would probably need to be registered differently than in a non-augmented user.

While all the potential use cases above remain hypothetical for now, some use of pills for interaction seems to be just around the corner. At the 2013 D11 conference, e.g., Motorola showed a pill that, when ingested, essentially turns the body into an authentication token[1]. While a pill like this just uses the body to power up, it still could be a way to prime users for accepting that some interactions require them to take a pill.

[1] http://allthingsd.com/20130603/passwords-on-your-skin-and-in-your-stomach-inside-googles-wild-motorola-research-projects-video/

## Notes on Potential Study Design

When evaluating how performance-enhancing drugs aid in human-computer interaction, we are faced with strong hurdles. Studies involving pharmaceuticals, for example, often require a more restrictive approval process with an ethical review board (or institutional review board). With no clear health benefit associated with the interactions, but health risks due to the drugs used, it is harder to make a clear case for this kind of investigation. Human-computer interaction researchers also are generally not trained to, e.g., respond to medical complications or other issues arising from the use of medical drugs.

Alternatively, researchers could look for participants already taking a drug whose effect on interactions is to be investigated. This would be easiest with drugs seeing widespread use already (e.g., Ritalin at some institutions). However, participants could be unwilling to admit which substances they use. Furthermore, when participants already use a substance it becomes much harder to control for amount taken or tolerance.

Instead of evaluating actual pharmaceuticals, some of the effects could be investigated by resorting to placebos [4]. In this case, we could still get some effect even though no active substance is used. The placebo effect can be quite strong and has been shown to even exist in animals [19]. Even though no active substance would be administered, placebos can still have harmful effects though. Those negative reactions have been described as the nocebo effect [15]. Hence, while we can reduce the risk by not administering actual drugs to participants, there would still be a risk associated with studying the effect on human-computer interactions.

If a study was performed with actual drugs or with placebos, some additional aspects on top of standard

study procedures would apply. In contrast to most human-computer interaction studies, such a study should be double blind—experimenters should not be aware whether they are administering an active substance or a placebo. Otherwise, experimenters might, e.g., show increased nervousness in the active substance trial, thus influencing the participant. Studies would ideally be between-subjects, as within-subjects studies require more careful control. For example, in a within-subjects study with an active ingredient one would have to make sure any effect has worn off when running the placebo condition second. This timeframe might be hard to determine and for some drugs might be prohibitively long. To ensure more natural interaction behavior it would be desirable to have a more casual setting (i.e., nothing like a hospital or doctor's practice).

## Discussion

Augmenting human ability through substance-use is a controversial issue. And, in fact, medical development in this area might never reach a point where human-computer interaction practitioners and researchers are faced with how to react to those kind of drugs. However, we feel it is worthwhile to ponder the consequences. Traditionally, we see the human user and her level of achievable performance as a fixed constant (within the natural variation, of course). Along the ideas of transhumanism though, this might at some point in the future cease to be the case. Then, designing systems for users could change to designing users and systems in symbiosis. We have already seen investigations on how to embed interactive devices under a users skin [13], or how users might interact with a display-enhanced forearm [21]. With *Augmented Human* SIGCHI actually already has a whole conference dedicated to this endeavor.

However, we should not ignore the large amount of issues should this reality materialize. There certainly are issues of safety to be addressed, though we should not immediately assume that any enhancement is inherently unsafe. While safety is an important aspect, we believe opposition or approval would most likely not be based on this. Instead, such augmentation could be seen by many as an attack on their human identity—as others augment to elevate their skills beyond the level usually achievable ("playing god" so to speak) the bar is raised for everyone else.

In many's view performance-enhancement and medicine are at odds, with one focusing on healing and the other on change of healthy individuals not in need of intervention. However, this argument is not that clear cut with many fields of medicine already not purely focused on healing. What about the plastic surgeon lifting a face, the dermatologist removing a liver spot, the orthodontist fitting braces to make that smile just a little better, or the sport physician helping athletes train just a bit more efficiently? This certainly is not black or white and what kind of enhancement is acceptable, or when, is yet to be determined (and probably will be subject to change).

One could argue that the idea of changing users is fundamentally in opposition to the overall goal of technology: to empower users. Where, e.g., human memorization falls short, a computer system can help users with easy access to large data stores—essentially lifting the need for much memorization in the first place. Along those lines, Nake has argued that all of computer science strives, in its essence, to move mental work from the human to the machine [20]. So why boost humans instead of giving them more powerful tools that relieve cognitive load where possible, freeing them from some tasks to be able to focus more on other aspects?

However, both goals do not necessarily run contrary to each other. One could have systems boosting human skill and yet still augment that skill in a supplemental way with performance-enhancing drugs.

## Conclusion

Performance-enhancing drugs could change the way we learn, work, and interact in the future. At this point it is hard to tell what this would look like. We should use the chance to early on discuss how this could impact the field—how it could benefit and what adverse effects it could have. Ultimately, human-computer interaction researchers will not be the ones designing such performance-enhancers, but human-computer interaction practitioners could have to design and build for a target audience that is performance-enhanced.

In *Brave New World*, Huxley has painted us a dystopian image of a society composed of humans "custom-grown" via chemical conditioning for their intended roles. The society he portrayed is depending on drugs to work and shuns those not fitting in. While bearing some similarities, it would remain to be seen whether enhancing human performance along the lines described here would take us down a similar road.


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## References


[1] Baumeister, R. F., Bratslavsky, E., Muraven, M., and Tice, D. M. Ego Depletion: Is the Active Self a Limited Resource? *Journal of Personality and Social Psychology 74*, 5 (1998), 1252–1265.

[2] Cakic, V. Smart drugs for cognitive enhancement: ethical and pragmatic considerations in the era of cosmetic neurology. *Journal of medical ethics 35*, 10 (Oct. 2009), 611–615.

[3] Card, S. K., Moran, T. P., and Newell, A. *The Psychology of Human-Computer Interaction*. Lawrence Erlbaum Associates, Hillsdale, NJ, USA, 1983.

[4] Enck, P., Benedetti, F., and Schedlowski, M. New insights into the placebo and nocebo responses. *Neuron 59*, 2 (July 2008), 195–206.

[5] Farah, M. J., Illes, J., Cook-Deegan, R., Gardner, H., Kandel, E., King, P., Parens, E., Sahakian, B., and Wolpe, P. R. Neurocognitive enhancement: what can we do and what should we do? *Nature reviews. Neuroscience 5*, 5 (May 2004), 421–5.

[6] George, T. P., Vessicchio, J. C., Termine, A., Jatlow, P. I., Kosten, T. R., and OMalley, S. S. A preliminary placebo-controlled trial of selegiline hydrochloride for smoking cessation. *Biological Psychiatry 53*, 2 (Jan. 2003), 136–143.

[7] Gervain, J., Vines, B. W., Chen, L. M., Seo, R. J., Hensch, T. K., Werker, J. F., and Young, A. H. Valproate reopens critical-period learning of absolute pitch. *Frontiers in systems neuroscience 7*, 102 (Jan. 2013), 1–11.

[8] Gore, R. K., Webb, T. S., and Hermes, E. D. A. Fatigue and Stimulant Use in Military Fighter Aircrew During Combat Operations. *Aviation, Space, and Environmental Medicine 81*, 8 (Aug. 2010), 719–727.

[9] Greely, H., Sahakian, B., Harris, J., Kessler, R. C., Gazzaniga, M., Campbell, P., and Farah, M. J. Towards responsible use of cognitive-enhancing drugs

by the healthy. *Nature 456*, 7223 (Dec. 2008), 702–705.

[10] Grön, G., Kirstein, M., Thielscher, A., Riepe, M. W., and Spitzer, M. Cholinergic enhancement of episodic memory in healthy young adults. *Psychopharmacology 182*, 1 (Oct. 2005), 170–9.

[11] Hall, S. S. The Quest for a Smart Pill. *Scientific American 289*, 3 (Sept. 2003), 54–65.

[12] Hartgens, F., and Kuipers, H. Effects of Androgenic-Anabolic Steroids in Athletes. *Sports Medicine 34*, 8 (2004), 513–554.

[13] Holz, C., Grossman, T., Fitzmaurice, G., and Agur, A. Implanted user interfaces. In *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems - CHI '12*, ACM Press (New York, New York, USA, 2012), 503–512.

[14] Ilieva, I. P., and Farah, M. J. Enhancement stimulants: perceived motivational and cognitive advantages. *Frontiers in neuroscience 7* (Jan. 2013), 198:1–198:6.

[15] Kennedy, W. The nocebo reaction. *Medical world 95* (Sept. 1961), 203–5.

[16] Leonard, B. E., McCartan, D., White, J., and King, D. J. Methylphenidate: a review of its neuropharmacological, neuropsychological and adverse clinical effects. *Human psychopharmacology 19*, 3 (Apr. 2004), 151–80.

[17] Low, K. G., and Gendaszek, A. E. Illicit use of psychostimulants among college students: A preliminary study. *Psychology, Health & Medicine 7*, 3 (Aug. 2002), 283–287.

[18] Minzenberg, M. J., and Carter, C. S. Modafinil: a review of neurochemical actions and effects on cognition. *Neuropsychopharmacology : official publication of the American College of Neuropsychopharmacology 33*, 7 (June 2008), 1477–502.

[19] Muñana, K. R., Zhang, D., and Patterson, E. E. Placebo effect in canine epilepsy trials. *Journal of veterinary internal medicine / American College of Veterinary Internal Medicine 24*, 1 (2010), 166–170.

[20] Nake, F. Informatik und die Maschinisierung von Kopfarbeit. In *Sichtweisen der Informatik SE - 14*, W. Coy, F. Nake, J.-M. Pflüger, A. Rolf, J. Seetzen, D. Siefkes, and R. Stransfeld, Eds., Theorie der Informatik. Vieweg+Teubner Verlag, 1992, 181–201.

[21] Olberding, S., Yeo, K. P., Nanayakkara, S., and Steimle, J. AugmentedForearm: exploring the design space of a display-enhanced forearm. In *Proceedings of the 4th Augmented Human International Conference on - AH '13*, ACM Press (New York, New York, USA, 2013), 9–12.

[22] Savulescu, J., Foddy, B., and Clayton, M. Why we should allow performance enhancing drugs in sport. *British journal of sports medicine 38*, 6 (Dec. 2004), 666–670.

[23] Turner, D. C., Robbins, T. W., Clark, L., Aron, A. R., Dowson, J., and Sahakian, B. J. Cognitive enhancing effects of modafinil in healthy volunteers. *Psychopharmacology 165*, 3 (Jan. 2003), 260–269.

[24] van Duinen, H., Lorist, M. M., and Zijdewind, I. The effect of caffeine on cognitive task performance and motor fatigue. *Psychopharmacology 180*, 3 (July 2005), 539–47.

[25] Vastag, B. Poised to challenge need for sleep, "wakefulness enhancer" rouses concerns. *JAMA : the journal of the American Medical Association 291*, 2 (Jan. 2004), 167–70.

[26] Warren, O. J., Leff, D. R., Athanasiou, T., Kennard, C., and Darzi, A. The neurocognitive enhancement of surgeons: an ethical perspective. *The Journal of surgical research 152*, 1 (Mar. 2009), 167–72.