



## George A. Alvarez

### Award for Distinguished Scientific Early Career Contributions to Psychology

#### Citation

“For significant contributions to our understanding of visual cognition, visual attention, and visual memory. George A. Alvarez has transformed current research by demonstrating that visual working memory is a flexible resource, by revealing that, outside the focus of attention, people store only statistical representations, and by extending our understanding of how we remember thousands of objects and scenes. He is recognized as well for leading with enthusiasm and insight and for inspiring others through his work and through his outreach efforts to educate a new generation of experimental psychologists.”

#### Biography

George A. Alvarez was born in Honolulu, Hawaii, but was raised primarily in Watsonville, California, the Strawberry Capital of the World and host of the annual Burrito Bash. Growing up, Alvarez attended California public schools (T. S. MacQuiddy Elementary, E. A. Hall Middle School, and Watsonville High), and the last thing he dreamed of becoming was a college professor—not because it would be difficult to achieve (indeed, not knowing that probably helped) but because he had no concept of what a professor really was or what it would take to become one.

Alvarez had always planned to go to college but was never really sure where he should apply. Then, out of the

blue in his junior year of high school, he received a Princeton University Alumni Book Award. To this day, Alvarez has no idea who nominated him for that award, but whoever it was dramatically altered the course of his life. Alvarez applied only to Princeton (he claims to be smarter than that now) and fortunately was admitted (his backup plan was to join the Navy, which was his mom’s least favorite option, but which he thinks would have been fine).

After two years of varsity football and aerospace engineering at Princeton (a rare combination that he cannot highly recommend), Alvarez unceremoniously retired from football and took his first psychology course with Ron Kinchla. That turned out to be a fantastic decision: Kinchla was the very first professor to take a personal interest in Alvarez (he took a personal interest in everyone, but that’s beside the point). Alvarez quickly learned that when meeting with Kinchla, he had to schedule an extra hour for chit-chat, great stories, and worldly advice. Alvarez wrote his senior thesis with Kinchla, “Attention to Hierarchically Structured Visual Images,” and was immediately hooked on the study of perception and attention.

With graduation approaching, Alvarez had found his field (psychology) and his topic (visual perception, attention, and memory) but was not yet prepared for graduate school. Fortunately, someone in the department had taken the time to print out and post a job announcement for a research assistant position at Harvard Medical School. That announcement described a list of requirements that might as well have read, “If you did a thesis with Ron Kinchla, we want you!” So Alvarez responded to that posting with a great deal of enthusiasm, explaining at length how everything he had done as an undergraduate had perfectly positioned him for *this* research assistant position. It turns out that was true: That job was with Jeremy Wolfe, who had also attended Princeton, who had also done a thesis with Ron Kinchla, and whose thesis also focused on the perception of hierarchically structured images!

Alvarez got the job. But it was more than a job. Research assistants in Wolfe’s lab receive a crash course in psychological science, with extensive training at every level, including how to formulate interesting/testable hypotheses, how to ground those ideas in tightly controlled experiments, and how to communicate their findings to a broad audience. Those who have had the pleasure of hearing Jeremy Wolfe give a talk understand that he’s a singular talent and that it isn’t worth emulating his particular *delivery style*. But it is worth trying to emulate his *content style* (level of detail vs. abstraction, and the intellectual punch he delivers consistently). The value of communication in science, and how to approach that challenge in our particular discipline, is probably the most important thing Alvarez learned in the Wolfe lab (but there were so many lessons, who can say for sure?).

After this tremendous pregraduate training opportunity, Alvarez was convinced that he was in the right field, that he

wanted to pursue a doctorate in cognitive psychology, and that he wanted to run his own lab. When he was first applying to graduate school, his most trusted senior advisor said, "If you get the chance to work with Patrick Cavanagh, take it." He got the chance, and he took it, doing his PhD work with Patrick Cavanagh in the Vision Sciences Laboratory at Harvard University.

Cavanagh was an extraordinary graduate student advisor. He's a fountain of knowledge, and the intellectual value system he passes on to his students is composed of sage advice like, "Listen to your data. It may not be telling you what you expect or what you want, but it is a message from the natural world that must be treated with respect to be heard" (*Current Biology*, <http://dx.doi.org/10.1016/j.cub.2014.01.066>). Who can ask for more from graduate school, really?

One time, in graduate school, Alvarez temporarily blinded Patrick Cavanagh. The incident involved a giant flash bulb (the kind you would put on a runway so that airplanes can find the landing strip at night) and a large auditorium of dark-adapted undergraduate students (who were utterly safe; only Cavanagh was in harm's way). The plan was simple: They'd all sit in the dark for 15 minutes while Cavanagh kept them entertained. Then Alvarez would jump from a tall table at the front of the room, looming above the crowd of students and activating the flash bulb as he reached the apex of his jump. The effect would be glorious, as the entire classroom would be treated to an afterimage of Alvarez soaring toward them. What could go wrong? Pop!—the flash went off unexpectedly while Cavanagh happened to be standing right in front of it. Cavanagh finished the lecture with his usual panache and no sign of ill effect. But afterward, when Alvarez asked if he was okay, all he said was, "I see blood." It wasn't really blood of course, and as Alvarez remembers it, Cavanagh's vision fully recovered.

Just as Cavanagh was an extraordinary advisor, the "Visionlab" at Harvard was an extraordinary lab. At the time, it was co-directed by Ken Nakayama and Patrick Cavanagh, and the slate of previous lab members was a veritable who's who in vision science (<http://visionlab.harvard.edu/VisionLab/members.alumni.php>). This successful alumni record was no doubt a product of the intellectual environment Ken and Patrick had fostered and of their invaluable contributions to the work their students and postdocs were doing. Becoming part of the Visionlab meant that Alvarez was immediately part of a large academic family, and the support of this broader community has had a major (often intangible) impact on his career.

After graduate school, Alvarez landed a postdoctoral fellowship with Aude Oliva in the Department of Brain and Cognitive Sciences at the Massachusetts Institute of Technology (MIT). Given its focus on biology, technology, computational modeling, and ambitious research programs, MIT provided all of the culture shock that "going somewhere new" is supposed to provide a young scientist, despite being

just down the river from Harvard. For Alvarez, it was exciting to be immersed in so many new ideas and approaches. Oliva, in particular, fostered an environment of fearless exploration, encouraging students and postdocs to break outside the usual bounds of their respective disciplines. Perhaps most important, at MIT Alvarez met Talia Konkle, who quickly became a close collaborator and is now his wife and life partner. MIT was a good place to be.

During the final year of Alvarez's postdoc, something unexpected happened. Patrick Cavanagh decided to leave the Visionlab at Harvard, taking a position at Université Paris Descartes. Given a variety of personal and academic factors too numerous to describe here, this presented Alvarez with a fateful opportunity too good to pass up.

Alvarez is currently the John L. Loeb Associate Professor of the Social Sciences at Harvard University, where he is co-director of the Vision Sciences Laboratory (along with Ken Nakayama and Yaoda Xu). Alvarez's research focuses on questions about our cognitive capacities: What limits the amount of information we can process at once? How should we characterize these capacity limitations? How do they limit learning, thinking, and problem solving? How can we train and improve our cognitive capacities? What efficient mechanisms has the system developed to cope with its capacity limits? He uses human behavioral experiments/psychophysics, computational modeling, and neuroimaging to explore the mechanisms underlying human visual cognitive abilities (perception, attention, and memory).

Alvarez is fortunate and thankful for his many fantastic mentors, both official (Ron Kinchla, Jeremy Wolfe, Patrick Cavanagh, and Aude Oliva) and unofficial (Todd Horowitz, Dan Simons, Brian Scholl, and Ken Nakayama), who taught him what a professor really is and how to become one. He can only hope, and strive, to have as much positive influence on the careers of his own students and postdocs.

## Selected Bibliography

- Alvarez, G. A. (2011). Representing multiple objects as an ensemble enhances visual cognition. *Trends in Cognitive Sciences*, 15(3), 122–131. doi:10.1016/j.tics.2011.01.003
- Alvarez, G. A., & Cavanagh, P. (2004). The capacity of visual short-term memory is set both by visual information load and by number of objects. *Psychological Science*, 15(2), 106–111. doi:10.1111/j.0963-7214.2004.01502006.x
- Alvarez, G. A., & Cavanagh, P. (2005). Independent resources for attentional tracking in the left and right visual hemifields. *Psychological Science*, 16(8), 637–643. doi:10.1111/j.1467-9280.2005.01587.x
- Alvarez, G. A., & Franconeri, S. L. (2007). How many objects can you attentively track? Evidence for a resource-limited tracking mechanism. *Journal of Vision*, 7(13), Article 14. doi:10.1167/7.13.14
- Alvarez, G. A., Horowitz, T. S., Arsenio, H. C., DiMase, J. S., & Wolfe, J. M. (2005). Do multielement visual tracking and visual search draw continuously on the same visual attention resources? *Journal of Experimental Psychology: Human Perception and Performance*, 31(4), 643–667. doi:10.1037/0096-1523.31.4.643a
- Alvarez, G. A., & Oliva, A. (2008). The representation of simple ensemble features outside the focus of attention. *Psychological Science*, 19(4), 392–398. doi:10.1111/j.1467-9280.2008.02098.x

- Alvarez, G. A., & Oliva, A. (2009). Spatial ensemble statistics are efficient codes that can be represented with reduced attention. *PNAS: Proceedings of the National Academy of Sciences, USA*, *106*, 7345–7350. doi:10.1073/pnas.0808981106
- Alvarez, G. A., & Scholl, B. J. (2005). How does attention select and track spatially extended objects? New effects of attentional concentration and amplification. *Journal of Experimental Psychology: General*, *134*(4), 461–476. doi:10.1037/0096-3445.134.4.461
- Brady, T. F., & Alvarez, G. A. (2011). Hierarchical encoding in visual working memory: Ensemble statistics bias memory for individual items. *Psychological Science*, *22*(3), 384–392. doi:10.1177/0956797610397956
- Brady, T. F., Konkle, T., & Alvarez, G. A. (2009). Compression in visual working memory: Using statistical regularities to form more efficient memory representations. *Journal of Experimental Psychology: General*, *138*(4), 487–502. doi:10.1037/a0016797
- Brady, T. F., Konkle, T., Alvarez, G. A., & Oliva, A. (2008). Visual long-term memory has a massive storage capacity for object details. *PNAS: Proceedings of the National Academy of Sciences, USA*, *105*(38), 14325–14329. doi:10.1073/pnas.0803390105
- Brady, T. F., Konkle, T., Gill, J., Oliva, A., & Alvarez, G. A. (2013). Visual long-term memory has the same limit on fidelity as visual working memory. *Psychological Science*, *24*(6), 981–990. doi:10.1177/0956797612465439
- Carlson, T. A., Alvarez, G. A., & Cavanagh, P. (2007). Quadratic deficit reveals anatomical constraints in attentional tracking. *PNAS: Proceedings of the National Academy of Sciences, USA*, *104*(33), 13496–13500. doi:10.1073/pnas.0702685104
- Cavanagh, P., & Alvarez, G. A. (2005). Tracking multiple targets with multifocal attention. *Trends in Cognitive Sciences*, *9*(7), 349–354. doi:10.1016/j.tics.2005.05.009
- Cohen, M. A., Alvarez, G. A., & Nakayama, K. (2011). Natural scene perception requires attention. *Psychological Science*, *22*(9), 1165–1172. doi:10.1177/0956797611419168
- Cohen, M. A., Konkle, T., Rhee, J. Y., Nakayama, K., & Alvarez, G. A. (2014). Processing multiple visual objects is limited by overlap in neural channels. *PNAS: Proceedings of the National Academy of Sciences, USA*. Advance online publication. doi:10.1073/pnas.1317860111
- Konkle, T., Brady, T. F., Alvarez, G. A., & Oliva, A. (2010). Conceptual distinctiveness supports detailed visual long-term memory for real-world objects. *Journal of Experimental Psychology: General*, *139*(3), 558–578. doi:10.1037/a0019165
- Konkle, T., Brady, T. F., Alvarez, G. A., & Oliva, A. (2010). Scene memory is more detailed than you think: The role of categories in visual long-term memory. *Psychological Science*, *21*(11), 1551–1556. doi:10.1177/0956797610385359
- Suchow, J. W., & Alvarez, G. A. (2011). Motion silences awareness of visual change. *Current Biology*, *21*(2), 140–143. doi:10.1016/j.cub.2010.12.019
- Wolfe, J. M., Alvarez, G. A., & Horowitz, T. S. (2000, August 17). Attention is fast but volition is slow. *Nature*, *406*, 691. doi:10.1038/35021132