

PALMs

Perceptual Adaptive Learning Modules

PUBLICATIONS RELEVANT TO INSIGHT'S LEARNING PRODUCTS

Insight's medical learning products grow out of extensive scientific research at the UCLA Human Perception Laboratory and the David Geffen UCLA School of Medicine. This document lists scientific publications relating to Insight's medical learning products and their basis in scientific research. The first section includes articles that provide evidence relating to the scientific foundations in perception, perceptual learning, memory, adaptive learning, and learning technology. The second section includes articles that specifically test our learning technology in real-world learning domains, including medical learning domains. Peer-reviewed papers in scientific journals or edited volumes are marked with an asterisk (*). Some papers that contain both significant basic research advances and tests of applications in real-world learning appear in both sections.

I. Basic Scientific Research Establishing the Effectiveness of Perceptual and Adaptive Learning Technology

* **Mettler, E.M., Massey, C.M. & Kellman, P.J. (2016).** A comparison of adaptive and fixed schedules of practice. *Journal of Experimental Psychology: General*, 145(7): 897-917.

* **Unuma, H., Hasegawa, H. , & Kellman, P.J. (2016).** Perceptual learning facilitates precise mental representations of fractions. *The Journal of Kawamura Gakuen Women's University*. 27(1), 35-49.

* **Thai, K.P., Krasne, S. & Kellman, P.J. (2015).** Adaptive perceptual learning in electrocardiography: The synergy of passive and active classification. In Noelle, D. C., Dale, R., Warlaumont, A. S., Yoshimi, J., Matlock, T., Jennings, C. D., & Maglio, P. P. (Eds.) *Proceedings of the 37th Annual Meeting of the Cognitive Science Society*. Austin, TX: Cognitive Science Society, 2350-2355.

* **Bufford, C.A., Mettler, E., Geller, E.H. & Kellman, P.J. (2014).** The psychophysics of algebra expertise: Mathematics perceptual learning interventions produce

durable encoding changes. In P. Bello, M. Guarini, M. McShane & B. Scassellati, (Eds.), *Proceedings of the 36th Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.

* **Mettler, E.M. & Kellman, P.J. (2014).** Adaptive response-time-based sequencing in perceptual learning. *Vision Research*, 99: 111-123.

* **Kellman, P. J. (2013).** Adaptive and perceptual learning technologies in medical education and training. *Military Medicine*. 178, 10: 98-106.

* **Kellman, P.J. & Massey, C. M. (2013).** Perceptual learning, cognition, and expertise. In Ross, B. (Ed.). *Psychology of Learning and Motivation, Volume 58*, Academic Press, Elsevier, Inc.

Wise, J. & Kellman, P.J. (2011). Changing the face of learning: Perceptual learning, the path to expert pattern recognition. *California Association of Independent Schools (CAIS) Faculty Newsletter*, Fall, 2011, 4-6.

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* **Mettler, E., Massey, C. & Kellman, P. (2011)**. Improving adaptive learning technology through the use of response times. In L. Carlson, C. Holscher, & T. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society*. Boston, MA: Cognitive Science Society, 2532-2537.

* **Thai, K.P. & Kellman, P. (2011)**. Basic information processing effects from perceptual learning in complex, real-world domains. In L. Carlson, C. Holscher, & T. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society*. Boston, MA: Cognitive Science Society.

* **Kellman, P.J., Massey, C.M & Son, J. (2010)**. Perceptual learning modules in mathematics: Enhancing students' pattern recognition, structure extraction, and fluency. *Topics in Cognitive Science* (Special Issue on Perceptual Learning), Vol. 2, Issue 2, 285-305.

Massey, C.M., Kellman, P.J., Roth, Z. & Burke, T. (2010). Perceptual learning and adaptive learning technology: Developing new approaches to mathematics learning in the classroom. In Stein, N.L. (Ed.), *Developmental and learning sciences go to school: Implications for education*. NY: Taylor & Francis.

Kellman, P.J. & Garrigan, P.B. (2009). Perceptual learning and human expertise. *Physics of Life Reviews*, Vol. 6, No. 2, 53-84.

* **Garrigan, P.B. & Kellman, P.J. (2008)**. Perceptual learning depends on perceptual constancy. *Proceedings of the National Academy of Sciences* (USA), Vol. 105, No. 6, 2248-2253.

* **Kellman, P.J., Massey, C.M., Roth, Z., Burke, T., Zucker, J., Saw, A., Aguero, K.E. & Wise, J.A. (2008)**. Perceptual learning and the technology of expertise: Studies in fraction learning and algebra. *Learning Technologies and Cognition: Special issue of Pragmatics & Cognition*, 16:2 (2008), 356-405.

* **Palmer, E.M., Clausner, T. C. & Kellman, P.J. (2008)**. Enhancing air traffic displays via perceptual cues. *ACM Transactions on Applied Perception* (TAP), Vol. 5(1), 1-22.

* **Kellman, P.J., Burke, T. & Hummel, J. (1999)**. Modeling the discovery of abstract invariants. In Stankewicz, B. & Sanocki, T. (Eds.). *Proceedings of The 7th Annual Workshop on Object Perception and Memory (OPAM)*, 48-51.

* **Kellman, P.J., Burke, T. & Hummel, J. (1999)**. Perceptual learning of abstract invariants. In Hahn, M. & Stoness, S.C. (Eds.). *Proceedings of the Twenty-First Annual Conference of the Cognitive Science Society*, Mahwah, NJ: Lawrence Erlbaum Associates, 264-269.

* **Kellman, P.J. & Kaiser, M.K. (1994)**. Perceptual learning modules in flight training. *Proceedings of the 38th Annual Meeting of the Human Factors and Ergonomics Society*, 1183-1187.

II. Formally Assessed Applications of Perceptual and Adaptive Learning Modules (PALMs) in Real-World Learning Domains

Medical Learning

Niemann, J.T., Stevens, C.D., Kellman, P.J. & Krasne, S. Mastering ECG Interpretation skills through a perceptual and adaptive learning module. *Under review, Advances in Health Science Education*.

* **Romito, B., Krasne, S., Kellman, P. & Dhillon, A. (in press)**. The impact of a perceptual and adaptive learning module on transesophageal echocardiography interpretation in anaesthesiology residents: A pilot study, *British Journal of Anaesthesia*.

* **Thai, K.P., Krasne, S. & Kellman, P.J. (2015)**. Adaptive perceptual learning in electrocardiography: The synergy of passive and active classification. In Noelle, D. C., Dale, R., Warlaumont, A. S., Yoshimi, J., Matlock, T., Jennings, C. D., & Maglio, P. P. (Eds.) *Proceedings of the 37th Annual Meeting of the Cognitive Science Society*. Austin, TX: Cognitive Science Society, 2350-2355.

* **Thai, K.P., Krasne, S. & Kellman, P.J. (2015)**. Perceptual learning with adaptively triggered comparisons (Published abstract). In Noelle, D. C., Dale, R., Warlaumont, A. S., Yoshimi, J., Matlock, T., Jennings, C. D., & Maglio, P. P. (Eds.) *Proceedings of the 37th Annual Meeting of the Cognitive Science Society*. Austin, TX: Cognitive Science Society, 3000.

* **Krasne, S., Rimoin, L., Altieri, L., Craft, N. & Kellman, P. (2015)**. Training pattern recognition of skin lesion morphology, configuration and distribution. *Journal of the American Academy of Dermatology*, 72(3):489-95. doi: 10.1016/j.jaad.2014.11.016. Epub 2015 Jan 13.

* **Krasne, S., Hillman, J.D., Kellman, P.J. & Drake, T.A. (2013)**. Applying perceptual and adaptive learning techniques to introductory histopathology for medical students. *Journal of Pathology Informatics*, 4: 34-41.

* **Krasne, S., Stevens, C.D., Kellman, P.J. & Craft, N. (2013, May)**. A tool for teaching pattern recognition in medical education. Paper presented at the 2013 Annual Meeting of the American Educational Research Association. Retrieved 2015 from the AERA Online Paper Repository. <http://www.aera.net/Publications/OnlinePaperRepository/AERAOnlinePaperRepository/tabid/12720/Owner/283639/Default.aspx>

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STEM (Science, Technology, Engineering & Mathematics) Learning

* **Bufford, C.A., Mettler, E., Geller, E.H. & Kellman, P.J. (2014).** The psychophysics of algebra expertise: Mathematics perceptual learning interventions produce durable encoding changes. In P. Bello, M. Guarini, M. McShane & B. Scassellati, (Eds.), *Proceedings of the 36th Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.

Ei-Ashmawy, A., Russell, A., Mettler, E., Burke, T., Kellman, P., & Massey, C. (2013, June). Adaptive and perceptual learning of chemical structure and nomenclature. Poster presented at Gordon Research Conferences: *Chemistry Education Research and Practice*. Newport, Rhode Island.

* **Mettler, E., Massey, C. & Kellman, P. (2011).** Improving adaptive learning technology through the use of response times. In L. Carlson, C. Holscher, & T. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society*. Boston, MA: Cognitive Science Society, 2532-2537.

* **Kellman, P.J., Massey, C.M & Son, J. (2010).** Perceptual learning modules in mathematics: Enhancing students' pattern recognition, structure extraction, and fluency. *Topics in Cognitive Science* (Special Issue on Perceptual Learning), Vol. 2, Issue 2, 285-305.

* **Massey, C.M., Kellman, P.J., Roth, Z. & Burke, T. (2010).** Perceptual learning and adaptive learning technology: Developing new approaches to mathematics learning in the classroom. In Stein, N.L. (Ed.), *Developmental and learning sciences go to school: Implications for education*. NY: Taylor & Francis.

* **Kellman, P.J., Massey, C.M., Roth, Z., Burke, T., Zucker, J., Saw, A., Aguero, K.E. & Wise, J.A. (2008).** Perceptual learning and the technology of expertise: Studies in fraction learning and algebra. *Learning Technologies and Cognition: Special issue of Pragmatics & Cognition*, 16:2 (2008), 356-405.

Wise, J.A., Kubose, T., Chang, N., Russell, A. and Kellman, P.J. (2000). Perceptual learning modules in mathematics and science instruction. In D. Lemke (Ed.) *Proceedings of the TechEd 2000 Conference*, Amsterdam: IOS Press.

Silva, A.B. & Kellman, P.J. (1999). Perceptual learning in mathematics: The algebra-geometry connection. In Hahn, M. & Stoness, S.C. (Eds.). *Proceedings of the Twenty-First Annual Conference of the Cognitive Science Society*, Mahwah, NJ: Lawrence Erlbaum Associates, 683-688.

Russell, A.A. & Kellman, P.J. Teaching automatic, 3-D recognition of chemical structures, *American Chemical Society Meeting*, Dallas, Texas, March, 1998.

Other Learning Domains

Flight Training:

Kellman, P.J., Stratechuk, T. & Hampton, S. (1999). Training pilots' pattern recognition skills: Perceptual learning modules (PLMs) in instrument flight training. In Wiggins, M. (Ed.) *Proceedings of the 2nd Annual Embry-Riddle Aeronautical University Flight Instructor Conference*, Daytona Beach, FL: Embry-Riddle University Press.

* **Kellman, P.J. & Kaiser, M.K. (1994).** Perceptual learning modules in flight training. *Proceedings of the 38th Annual Meeting of the Human Factors and Ergonomics Society*, 1183-1187.

Music Learning:

* **Bufford, C.A., Thai, K.P., Ho, J., Xiong, C., Hines, C. & Kellman, P.J. (2016).** Perceptual learning of abstract musical patterns: Recognizing composer style. *Proceedings of the 14th International Conference on Music Perception and Cognition*.

Geography Learning:

* **Mettler, E.M., Massey, C.M. & Kellman, P.J. (2016).** A comparison of adaptive and fixed schedules of practice. *Journal of Experimental Psychology: General*, 145(7): 897-917.

Chinese Character Learning:

* **Thai, K.P. & Kellman, P. (2011).** Basic information processing effects from perceptual learning in complex, real-world domains. In L. Carlson, C. Holscher, & T. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society*. Boston, MA: Cognitive Science Society.

Biological Classifications:

* **Mettler, E.M. & Kellman, P.J. (2014).** Adaptive response-time-based sequencing in perceptual learning. *Vision Research*, 99: 111-123.