Summary

We study tactile motion perception, use an adaptation paradigm, and need a good method for measuring adaptation to motion. Here we describe one we developed.

Dynamic test stimuli used by others (see below) present one motion direction at a time, or no direction. We present two opposite directions. This balanced two-component motion test is potentially the most sensitive and time-efficient measure - the slightest reduction in signal strength for the adapting direction should allow the opposite direction to win.

A robust tactile motion aftereffect using a two-component motion test stimulus

McIntyre, S[1,2,5]; Vickery, R[3]; Birznieks, I[4,5]; Holcombe, A O[1]; Seizova-Cajic, T[2]

(1) School of Psychology, University of Sydney; (2) Faculty of Health Sciences, University of Sydney
(3) University of New South Wales (4) University of Western Sydney; (5) Neuroscience Research Australia

Background

Motion aftereffect (MAE)

A neutral test stimulus appears to move in the opposite direction to the previously adapting motion.

Visual MAE - EASY to obtain

A nineteenth century engraving of the Falls of Foyers. The waterfall illusion was observed by Addams (1834) from the platform shown. *(from Wade & Zieffe, 2008).*

Static tests
e.g. rocks next to a waterfall
The rocks appear to drift upwards after viewing the falling water.

scan the QR code to view a demo

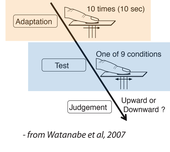
Dynamic tests
e.g. random dot kinematograms
Adapt with coherent motion in one direction, test with incoherent motion with dots moving in all directions.

Successfully used to study visual motion encoding.

Tactile MAE - DIFFICULT to obtain

Static tests
Attempted since early 20th c.
Found poor, inconsistent effects; no motion at all, or both positive and negative aftereffect.

Presumably because static stimuli barely excite tactile motion opponent mechanisms.



- from Watanabe et al, 2007

Dynamic tests
Produce reliable aftereffects.
Directional stimuli - apparent motion in pin arrays, varying in speed and direction (including simultaneous vibration for no motion)
The point of subjective equality (PSE) reveals aftereffects (Watanabe et al, 2007; Konkle et al, 2009).

Pin arrays stimulate the adapted sensory mechanisms when testing for aftereffects.

Hardly used to study tactile motion so far.

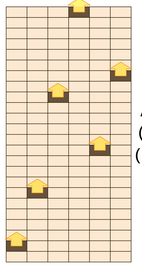
Method

Apparatus

"OPTACON" 24 x 6 = 144 pin tactile array (27.2 x 11.4mm)
pins vibrate at 230Hz
Stimulates FA receptors only (Gardner & Palmer, 1989).

Apparent Motion Stimulus

Successive adjacent pins contact the skin and vibrate



ADAPTATION
(Expt1: 2 min
(Expt2: 10 sec)

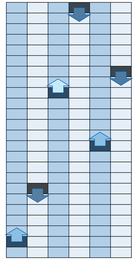
Task

Report perceived direction:
"distal", "proximal" or "unclear"
during both *adaptation* and *test* phases

Test stimulus

Two component motions in the test stimulus:

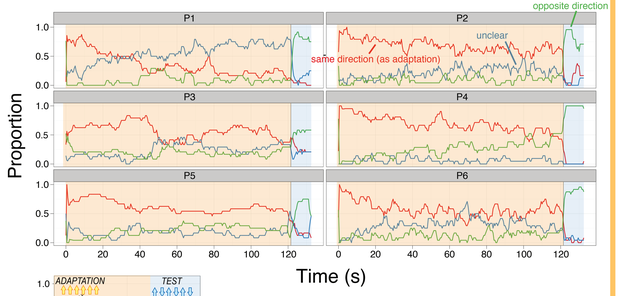
1. Same direction and speed (46 or 91mms^{-1}) as in the adapting stimulus
2. Opposite direction, otherwise same as the adapting stimulus

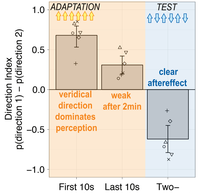


TEST
(10 sec)

Results

Strength of direction perception declines with adaptation, a clear aftereffect follows

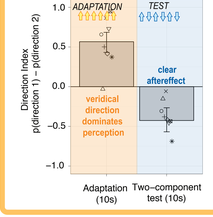




Experiment 1

Above: Individual results of 6 participants showing good perception of direction initially, its gradual loss and illusory reversals over the 2-min adaptation period, followed by a clear tMAE (green response in the shaded area). Proportions for 24 repeats of adaptation + test. (Two participants excluded because of poor initial direction perception).

Left: Group data. Dominant perceived direction in three 10s bins: at the beginning of adaptation, its end, and the test period. Note that tMAE (rightmost bar) is as strong as the initial perceived direction.

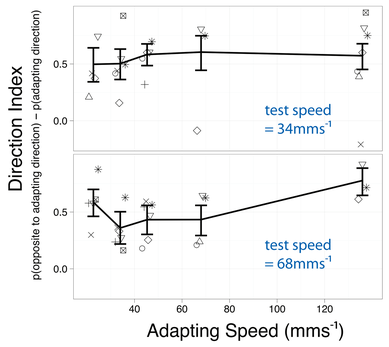


Experiment 2

Group data for 8 participants. Dominant perceived direction during a single 10s adaptation period and the following test period. Note that the the MAE is a similar strength to when adaptation lasted 2 minutes (Experiment 1).

10s is sufficient to obtain a strong aftereffect.

Speed tuning of the tMAE



Experiment 2

Preliminary group data for 8 participants. Strength of the tMAE (DI) for five adapting speeds (23 - 136mms^{-1}) and two test speeds (34 and 68mms^{-1}).

Work in progress
expected speed tuning is not evident

Discussion

Comparison of dynamic test stimuli

Previous pin array studies (Watanabe, Konkle)	Our two component motion
Uni-directional motion	Bi-directional motion
Appropriate stimulation of the adapted sensory channel	Appropriate stimulation of the adapted sensory channel
Stimulates FA receptors only (no skin stretch)	Stimulates FA receptors only (no skin stretch)
Speed and direction varied, PSE calculated from many trials (each with 10s adaptation).	Direction judgments reveal aftereffects with a single trial (10s adaptation).

Tactile arrays that produce apparent motion without skins stretch elicit no direction sensitivity in primary afferents (Pei et al, 2008). This suggests the tactile MAE observed here has a central basis.

References

1. Wade, N. J., & Zieffe, M. (2008). The surface and deep structure of the waterfall illusion. *Psychological research, 72(6).* 593-600.
2. Watanabe, J., Hayashi, S., Kajimoto, H., Tachi, S., & Nishida, S. (2007). Tactile motion aftereffects produced by appropriate presentation for mechanoreceptors. *Experimental Brain Research, 180(3),* 577-82.
3. Konkle, T., Wang, Q., Hayward, V., & Moore, C. I. (2009). Motion aftereffects transfer between touch and vision. *Current Biology, 19(9),* 745-50.
4. Gardner, E. P., & Palmer, C. I. (1989). Simulation of motion on the skin. I. Receptive fields and temporal frequency coding by cutaneous mechanoreceptors of OPTACON pulses delivered to the hand. *Journal of Neurophysiology, 62(6),* 1410 - 1436.
5. Pei, Y.-C., Hsiao, S. S., Craig, J. C., & Bensmaia, S. J. (2010). Shape invariant coding of motion direction in somatosensory cortex. *PLoS Biology, 8(2),* e1000305.

Supported by ARC DP110104691 to TSC and IB.