# Stimuli and Apparatus

## Prism Adaptation (PA)

[Tutoriel Adaptation prismatique (Prs Y. Rosseti et G. Rode) - YouTube](https://www.youtube.com/watch?v=5KUSH43HvuM)

Prism adaptation consists in asking the participants to make ballistic pointing movements with their right arm toward a target. The pointing error induced by the leftward (LPA) optic shift triggers adaptation processes that realign the visual and proprioceptive sensory coordinates. The rightward remapping of space (termed “after-effect”) induced by LPA is observable when the prism glasses are removed and the participant asked to point toward a visual target without feedback, or asked to indicate their straight ahead with the eyes closed. To be successful, the PA procedure must respect multiple constraints, involving multiple parameters:

* **Number of target:** it usually varies between 3 (Rode et al., 2015) and 9 (Michel & Cruz, 2015). Most of the time this number ranges between 3 and 4.
* **Presentation of target:** The targets (eg, white dots) can be stuck on a black cardboard (Rode et al., 2015) or displayed by mean of a tactile screen. For example, in the experiment of Striemer et al. (2016), the participants must press a button in the starting position to trigger the target presentation on the tactile screen. After the pointing movement, they brought back their hand on the button to trigger the presentation of the next target.
* **Order of pointing:** the target of interest can be signaled verbally by the experimenter, in a random sequence. The experimenter can make reference to a direction (“left”, “right”; Herlihey et al., 2012) or a number (1,2,3,4; Ronga et al., 2018).
* **Pace of pointing:** this parameter is linked to the previous one. In the experiment of Striemer et al. (2016) the pace was self-monitored. At variance, Herlihey et al. (2012) used a metronome to normalize the timing of pointing (1 trial = 2 sec).
* **Number of pointing:** this parameter would be crucial to produce the “true” adaptation component, this latter considered as an ultra-slow adaptation process (McIntosh et al., 2019; Prablanc et al., 2020). McIntosh et al. (2019) showed that the magnitude of the after-effects on the line bisection and landmark tasks was modulated by the length of the pointing procedure. After-effects were larger in the experiments where the participants pointed during more than 10 min (short exposure), in comparison to those where the participants pointed during less than 10 min (long exposure). Nevertheless, time may act as a proxy for the number of pointing movements, which indicates that the pacing of pointing is also important. Because short exposure is usually associated to 200 pointing, and long exposure associated to 300 pointing, McIntosh et al. (2019) recommended a minimum of 250 pointing. Nevertheless, some experiments have used LPA with short exposure (7-10 min, 150 pointing) and obtained substantial after-effects on the proprioceptive straight ahead (PSA) and the landmark task (Schintu et al., 2014, 2017). At the extreme opposite, some studies have applied exposure of 20 min (Colent et al., 2000; Michel & Cruz, 2015), without considering the number of pointing movements.
* **Measurement of pointing error:** The team of Lyon uses two electrodes: one tethered on the center of the black cardboard (aligned with the participant’s body midline), and one tethered on the index of the participant. When the index touches the table, a device registers the tension between the two electrodes. Then the position of the finger relative to the body midline (if correctly aligned with the cardboard electrode) can be computed, in angle. With other setting, the coordinates of the finger can also be registered by mean of a tactile screen (Gilligan et al., 2019).
* **Prism strength:** it varies between 8.5 and 17°, according to the studies. The larger the strength, the larger the after-effects (McIntosh et al., 2019). Although this relationship was indeed found with tasks involving proprioception of the right arm (PSA task, Line bisection task), it was not the case with a perceptual visual task (Landmark task, Michel & Cruz, 2015; Striemer et al., 2016).
* **Measurement of after-effects:** Traditionally PA after-effects are measured when after prism removal by means of three tasks: the visual straight ahead (VSA), the PSA, and the Open-loop pointing (OLP) task. These three tasks are thought to assess the visual, proprioceptive, and total (visual + proprioceptive) shifts, respectively (Hatada et al., 2006; Prablanc et al., 2020; Welch et al., 1974). As suggested by Prablanc et al. (2019), the PSA should be assessed with a passive movement of the arm in order to control for the motor component. Nevertheless, Hatada et al. (2006) have found no difference between the active and passive PSA immediately after prism removal. Besides these traditional tasks, the Landmark task have been extensively used from the early 2000’ in order to assess the *expansion* of the after-effects in other cognitive domains (Michel, 2016). Thus, LPA after-effects have been observed in the Landmark task (Colent et al., 2000), the Greyscale task (Loftus et al., 2009), the Number bisection task (Loftus et al., 2008), haptic perception (Girardi et al., 2004), and even on thermoregulation (Calzolari et al., 2016) and postural control (Michel et al., 2003). This expansion was also found in right brain-damaged patients, with therapeutic effects bearing on a large range of cognitive deficits (Jacquin-Courtois et al., 2013).

In sum, the procedure promoted by the team of Lyon can be used safely to determine the number of targets, target presentation, pace and order of pointing movements, and measurement of pointing error. This procedure can also be adapted on tactile screen if required. In all cases, the arm of the participant must be hidden in the starting position (terminal exposure), pointing movements must be rapid (and eventually paced by a metronome), and regular breaks (30 sec to 2 min) must be planned during the procedure. After-effects should be evaluated by at least on “sensori-motor” task (VSA, PSA, OLP), and eventually by one “perceptual” task (eg, Landmark task, Number bisection task, Greyscale task).

## Virtual Reality (VR)

## Proprioceptive Straight-Ahead (PSA) task

## Landmark task

## Visual Vertical (VV) task

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