Q1

27 February 2023 10:24

1a)

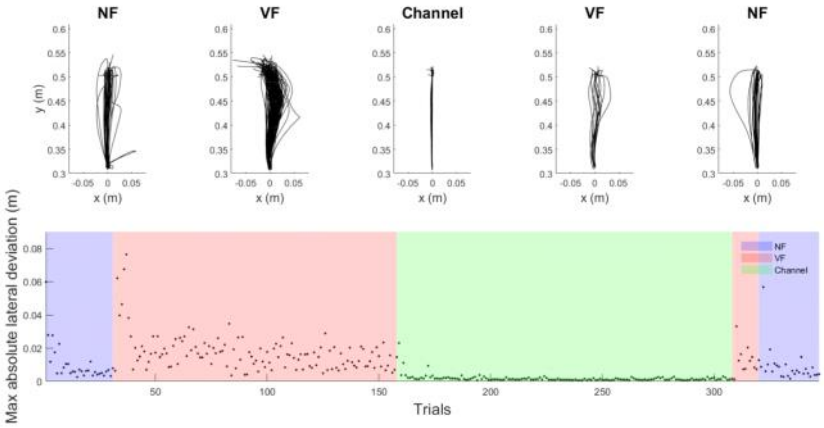


Figure 2: Motor adaptation of horizontal arm movements in a lateral force field. (a) paths in repeated reaching arm movements in five different phases with different force fields, and (b) maximum absolute lateral deviation during these phases.

The results from Fig.2 shows the reaching movement trajectories of human subjects change in a novel VF (velocity dependent force field). This is an A-B-A study where A is a VF and B is a force channel (i.e., when the interface guides the movement along x=0).

Subjects are trying to reach a target and, therefore, a straight trajectory to the target indicates a well-learned movement. This is shown more accurately by the maximum lateral deviation, a value close to 0 also indicates a well-learned movement.

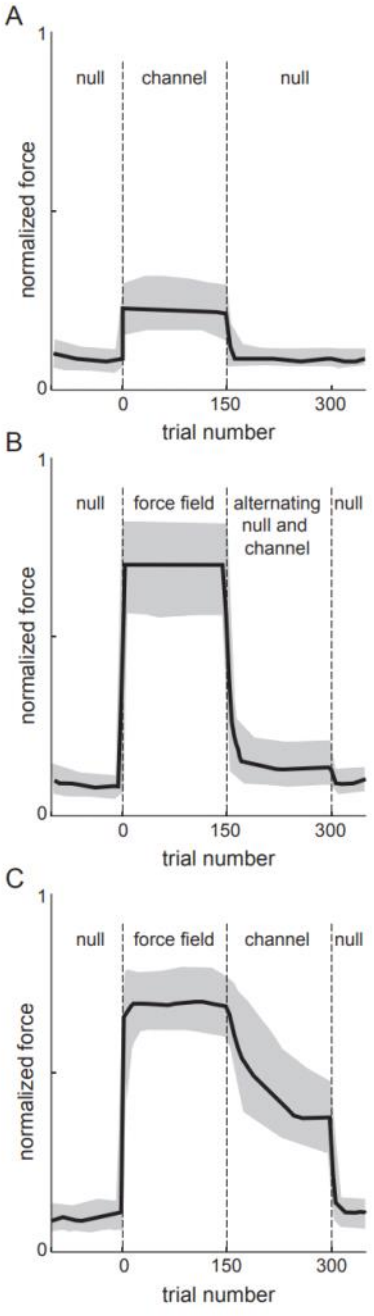
1. <u>The first graph shows a null force field (i.e., normal reaching movements with no forces applied).</u>
   - We assume the initial deviations of 0.03m is due to the subjects getting used to the apparatus.
   - This quickly drop to 0m deviations as the subject is adapted to moving in a NF.

2. <u>The second graph shows the first time the VF is applied.</u>
   - Here, we see **anterograde interference** since subjects' adaptation to the NF is interfering with their adaptation to the VF.
   - This explains why there are great absolute lateral deviation errors (common for anterograde interference).
   - The first few trials in this field get close to 0.08m deviation!

3. <u>The third graph shows the effects of a force channel.</u>
   - The experimenter is testing how the presence of kinematic error drives the learning process.
   - Previous experiments have a NF phase in-between the VF phases, called a catch trial. Immediately after the catch trial, there is an increase in trajectory error showing a transient reversal of learning. (Thoroughman & Shadmehr, 2000).
   - However, this rapid readaptation to the NF requires a kinematic error as shown by Scheidt et al. in 2000.
   - The haptic channel was used to show what happens when the kinematic error is reduced to zero.
   - It shows that when the kinematic error is reduced to almost zero, there is only a small amount of unlearning from the subject, as opposed to significant unlearning when a NF is used in-

between VF trials instead.

- So, **if we were to replace the channel phase with a catch trial (i.e., a NF phase)**, we would see a greater trajectory error (or a **greater maximum absolute lateral deviation)** following the catch trial.
- Interestingly, if we were to measure orthogonal forces to the direction of motion applied by the subject during the channel trial, we would see a much smaller force in the channel as opposed to in a NF phase (see figure below).



4. <u>The fourth graph shows the VF being applied to the subject again.</u>

- **Consolidation** is the ability of the subjects to retain motor memory after adapting to a novel force field.
- The question does not give information on how long was waited in between each phase which can explain the results.
- From previous studies, in an A-B-A test, adaptation to force field B immediately after A removed memory of A when tested the next day. (Brashers-Krug, Shadmehr & Bizzi, 1996)
- If there was an interval of at least 4 hours between A and B, the memory of A was retained 24-

hours later (sometimes up to five months later!). Furthermore, if B was learned 5.5 hours later, the aftereffects will be smaller. (Shadmehr & Brashers-Krug, 1997)
- In the graph showing **maximum lateral deviation,** the error is around 0.03m whereas when the VF field was first introduced to the subject it was close to 0.08m. This means the error is roughly a third of the original deviation. This suggests the interval between A and B in this study was at least 4 hours.
- Waiting longer than 4 hours after learning A means that the subject is no longer using short-term memory space to learn B.
- This shows that motor memory is liable like other memory systems. (Nader & Hardt, 2009) This means that once a new skill has been learned, it can be remembered for long periods of time with little reduction (even without recall).

5. <u>The fifth graph shows when the subject is exposed to a null-force field again (i.e., all forces are removed).</u>

- In the first one (or couple of) trials, the reaching movement is not straight showing the subject has adapted to the force-field and expects one to be there, so are correcting for the force themselves.
- **Interference** is the amount by which learning one task affects learning the other. Here, we see that adapting to the VF has affected moving in the NF, therefore, **retrograde interference** is present (as opposed to anterograde).
- Given it only takes a few trials until they have a straight trajectory again, this shows how quickly the subject adapts back to the initial condition of no force field.

1b)

The channel does not significantly hinder the retention of the motor adaptation in the first VF condition. The deviations in the VF phase ***after*** the channel are similar to the VF phase ***before*** the channel.

- **After the channel:** Initially the error was close to 0.08m but dropped to a maximum of 0.03m and a median of 0.01m.
- **Before the channel:** Constantly a maximum of 0.03m and a median of 0.01m (i.e. we do not see the high errors of 0.08m after the channel).

Consolidation is the ability of the subjects to retain motor memory after adapting to a novel force field. In this case, it is the subject's ability to retain motor memory of the VF field after the channel phase.

This is an A-B-A test where A is the VF field and B is the channel field. These types of tests are used to find the effects of different B fields or interval times etc for motor memory of the A field.

The presence of no kinematic error in the force channel means there is no transient reversal of learning. If a NF was used instead of a force channel in the B phase (i.e., include a catch trial) we would expect to see greater lateral deviations.

To allow for this retention to occur, based on previous studies, I would expect the time between trials to be greater than 4 hours. This means the short-term memory space is not being used and replaced by re-learning in the channel phase.

In an A-B-A test like this, adaptation to force field B immediately after A removed memory of A when tested the next day. (Brashers-Krug, Shadmehr & Bizzi, 1996) If there was an interval of at least 4 hours between A and B, the memory of A was retained 24-hours later (sometimes up to five months later!). Furthermore, if B was learned 5.5 hours later, the aftereffects will be smaller. (Shadmehr &

Brashers-Krug, 1997)

This shows that motor memory is liable like other memory systems. (Nader & Hardt, 2009) This means that once a new skill has been learned, it can be remembered for long periods of time with little reduction (even without recall).