detecting prediction errors
during haptic interaction

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1. motivation
both virtual / remote experiences require **visual and haptic sync** such as teleoperated surgery,
and VR experiences and simulators...
2. related work
rendering haptic realism
SMA pads [Merrett et al., '11]

REVEL [Bau et al., '12]

on-the-nail vibro [Ando et al., '02]

Teleact II [Brooks, '89]

CyberTouch [Virtual Technologies, '90]

3DOF fingerpad [Kim et al., '16]

... tactile haptics
& force feedback (exoskeleton or EMS)

[Letier, et al., '08]

[Lopes, et al., '15]
... and these haptic modalities have shown to boost realism but how do researchers evaluate this sense of realism? we ask users to subjectively judge it...
questionnaires requires:
1. stopping the experience
2. reflecting on it
3. judging it
4. get back to immersion
our research question: how to measure a subjective experience in a new way?
3. our approach
instead, we propose measuring the brain's response to visuo-haptic events
3D printed electrode spacers

64 channel EEG
4. experiment
sensory feedback:
1. visual
2. visual + vibro
3. visual + vibro + EMS
Match (75%)  Mismatch (25%)
5. results
1. ERPs in match (visuals & haptics in sync)
2. ERPs in mismatch (visuals & haptics in sync)
3. differential ERPs

- Visual (n=11)
- Visual+Vibro (n=11)
- Visual+Vibro+EMS (n=11)
EEG pipeline: how did we process the EEG signal?
EEG pipeline

- Raw
- Filtered
- Time-locked
- Epochsed
- Averaged
EEG pipeline

1. filtered
2. BSS / ICA
3. eye
4. line noise
5. epochs
6. ERP at FCz
EEG pipeline

1. filtered
2. BSS / ICA
3. eye
4. line noise
5. epochs
6. ERP at FCz
6. outlook
towards a multimodal approach
while we currently do this offline, we envision realtime assessment in VR

[Zander et al., PNAS ‘16]
7. conclusion
Sensory information ≠ expectation

ERPs during **prediction errors** to assess haptic mismatches

potential as a **complimentary presence experience** metric
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