

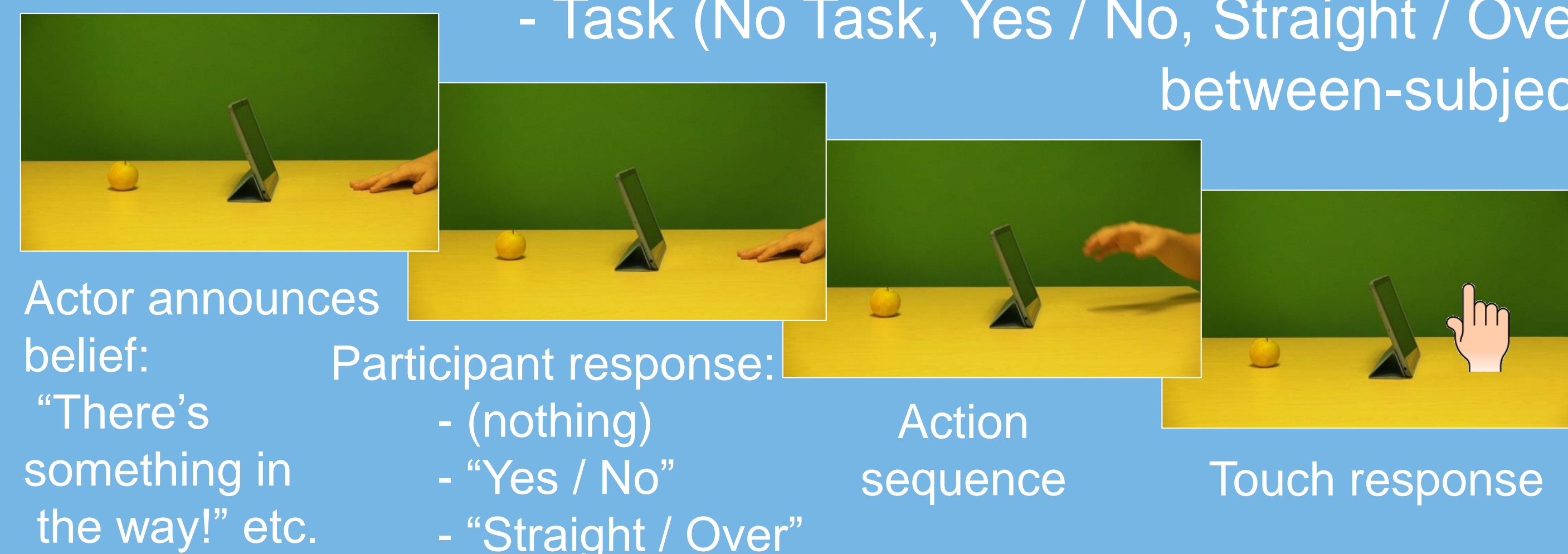
## Background

Recent models argue that social perception – and perception in general – is an inferential process, where prior knowledge and higher-level expectations about an actor's goals and beliefs guides our perceptual experience of their actions (Bach et al., 2014; Csibra, 2008; Kilner et al., 2007). We have recently developed a novel paradigm, capturing these goal expectations, and allowing us to accurately measure their influence on action perception. We demonstrated that expectations of efficient action bias action observation, such that actions were perceived to have reached higher when an obstacle was present, in line with the prediction that the actor would reach over it, and lower when an obstacle was not present (Hudson et al., 2018; McDonough et al., 2019). Here, we show that these biases are influenced by the beliefs attributed to the actor.

## Method

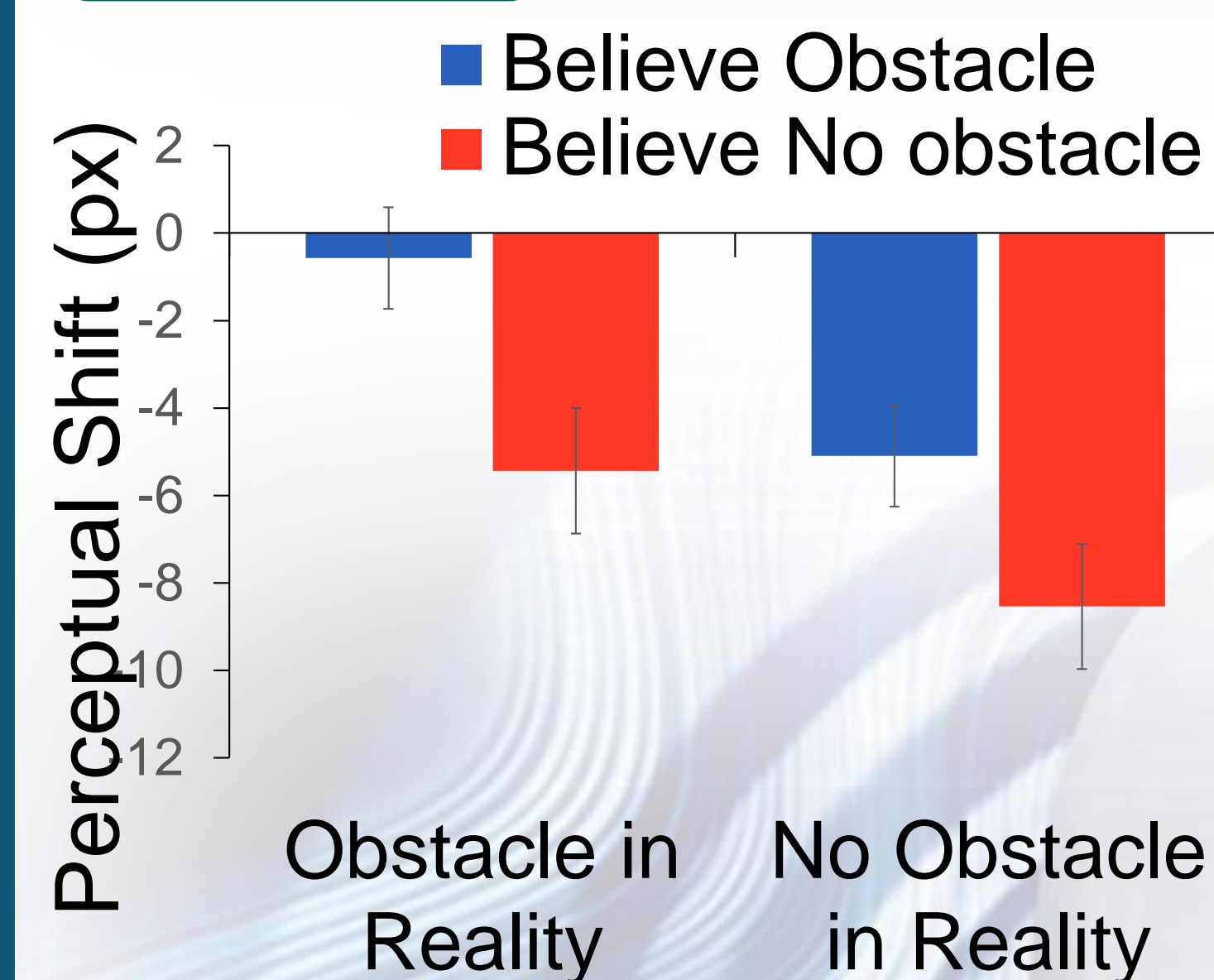
80 participants in 2x2x3 mixed design:

- Participant's (seen) Reality (Object vs No object).
- Actor's (announced) Belief (Object vs No object).
- Task (No Task, Yes / No, Straight / Over – between-subjects).



- Participants first see a static image of an actor's hand poised to reach the target object on the far left (i.e. apple). Sometimes there is an obstacle (i.e. iPad) in-between them, that the actor would have to reach over (in Reality).
- The actor then announces their Belief about the scene (if there is an obstacle or not) independent from Reality.
- The participant then either predicts the actor's action trajectory (Straight / Over), reports the actor's belief about obstacle presence (Yes / No) or has No Task.
- The actor then begins to reach for the object before their hand suddenly disappears from the scene.
- Participants indicate the last seen position of the actor's index finger on a touch-screen.

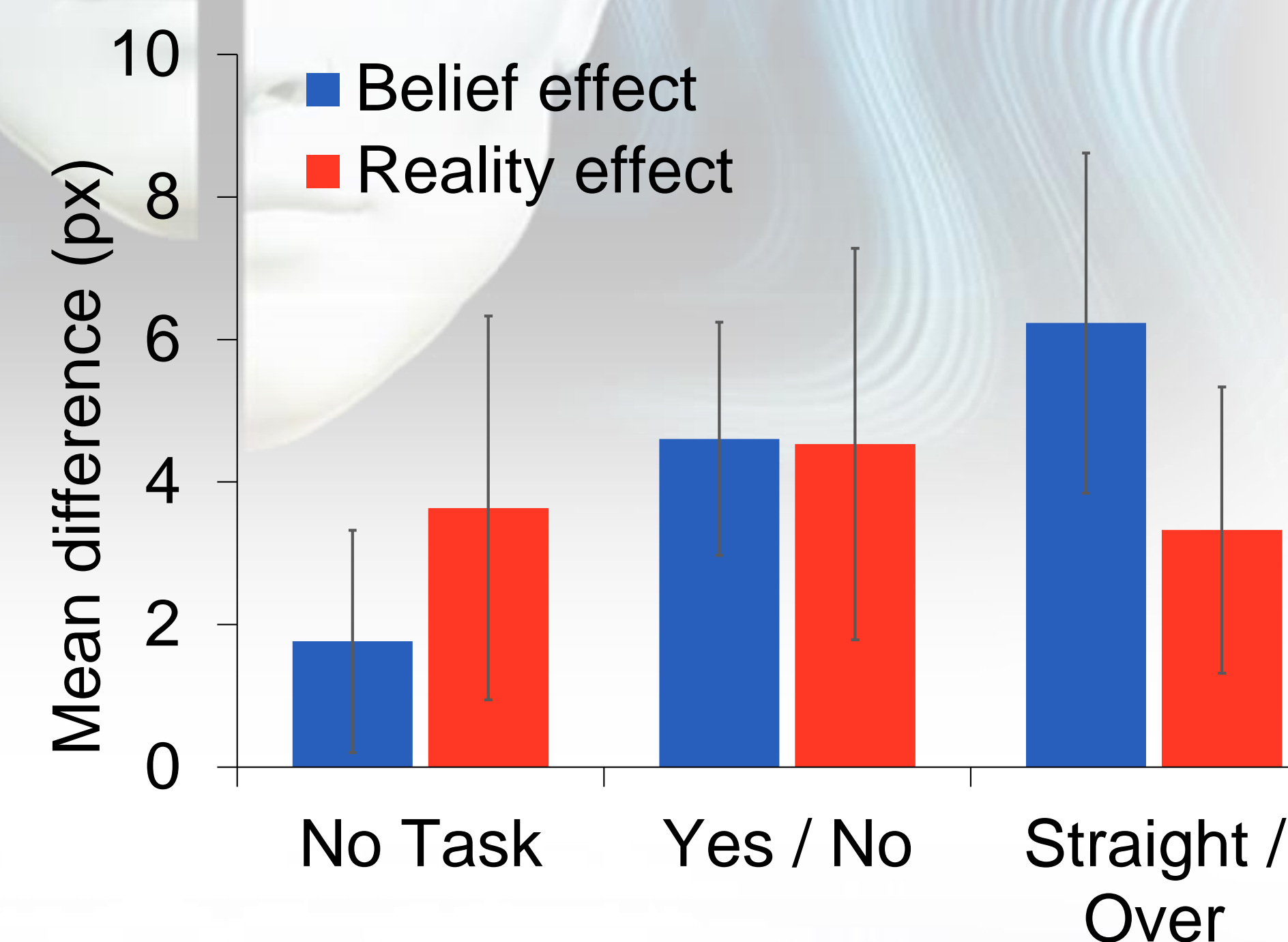
## Results



-These effects were present in all three tasks (all  $ps < .01$ ).

- While the size of the Reality effect remained consistent across all three tasks, the Belief effect increased when participants reported the belief of the actor (Y/N:  $p < .01$ ), and increased further when they predicted the actor's trajectory (S/O:  $p < .01$ ).

- Analysis was conducted on the difference between the real final coordinates of the hand and participant's selected coordinates (perceptual shift), along the X-axis and the Y-axis, separately.
- Y-axis data revealed a main effect of Reality ( $p < .001$ ) and of Belief ( $p < .001$ ).
- Perceived disappearance points were higher when there was an obstacle in Reality compared to no obstacle, and even higher when the actor Believed their was an obstacle.



## Discussion

- The Reality effect replicated previous experiments where action perception was corrected towards a more efficient trajectory (i.e. higher when obstacle is present and reach over is predicted).
- Perception was further shifted in line with the actor's Belief, even when this contradicted the visual (Reality) information.
- When the actor believed an obstacle was present, action perception shifted upwards as if the actor was seen to try and avoid the obstacle, even when no obstacle was visible to the participant (in Reality).
- This process was automatic, but increased with explicit processing of the actor's Belief.

## Conclusions

Here we provide evidence, for the first time, for a top-down influence of prior expectation on action observation, involving sophisticated higher-order processing of theory of mind ("mentalizing"), and reveal that our perceptual experience of others' actions is derived from an integration of bottom-up sensory information and high-level cognition.