Introduction to Cognitive Science - Term Paper 2

Examining evidence against the Action vs Perception Hypothesis proposed by Goodale & Milner (1992), with experiments on visual illusions

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Abstract

Ungerleide (1982) proposed based on lesion studies on monkeys that in primate brains, visual information was processed in two streams – dorsal and ventral. Goodale & Milner (1992) reinterpreted this theory, making a species jump to humans and suggesting that the dorsal stream had the purpose of guiding the manipulation of objects (action) and the ventral stream did the computations necessary for object recognition (perception). I have picked two papers that disagree with this, one via experimentation (Franz et al., 2000), and the other by an analysis of existing work at the time (Franz, 2001). In this term paper, I will be explaining the phenomenon being considered in the first place, the cognitive processes involved, a quick summary of the experiments and arguments, noted gaps in the treatment, potential extensions to the study, and my own suggestions on future experimentation.

What are we looking at?

Studies with visual illusions have been used to propose evidence for the separate visual processing pathways theory. We're looking at counter-arguments: studies that look at the same illusions with different experimental setups and justify why the original proposal is not so.

The original hypothesis, and responses

In brief: the theory is that primate visual system is organised into two parallel pathways. Goodale & Milner (1992) suggested extending it to humans too, using an experimental setup around the Ebbinghaus illusion. Hereon this will be referred to as 'the hypothesis.'

Experiments agreeing with the hypothesis came early, most significant of them being Aglioti et al. (1995). Over time, more critical studies have come about that tackle some of the gaps and flaws in the original experiments. I will be looking at one such response (Franz et al., 2000) that sets up an experiment contradicting Goodale's (1992) results, and also adds a few more to refute assumptions taken to be true in earlier work. I will also look at Franz (2001), that summarises publications on the topic at the time and highlights methodological concerns with the work agreeing with Goodale's (1992) original hypothesis.

The Cognitive Processes involved

- **Vision**:

  The first cognitive process being looked at is visual perception – the type required to correctly identify objects and perceive. The hypothesis suggests that this is a complex task as it involves elaborate processing for object recognition and conscious perception, and it takes up the *ventral* stream of processing. This processing gets tricked by illusions, as the vision for perception extrapolates from known experience (Doherty et al., 2010).

- **Motor**:

  The second cognitive process is motor skills, or more specifically, estimations that help guide motor movements based on observation. The idea is that the focus for such a task is on quick computation and short-term memory to quickly locate objects (that might be moving), hence bypassing the complex object recognition that the earlier process has to compute. This is said to take up the *dorsal* stream of processing.

What has been shown: The Experiments and Arguments

For a quick background, all the experiments generally look for the effect of illusions on perceptual and motor tasks. Work aligning with the separate visual pathway theory will show a higher effect impact on perceptual tasks than motor tasks.

Most of the experiments use the Ebbinghaus illusion. *Perception* is usually tested by asking the subject to try and adjust an external circle to match the size of the central circle. If both are given simultaneously, the task can be to try and adjust one or both of them to become the same size, but that is not necessary. For *action*, the common task is to ask the subject to grasp the central circle (which is always a physical object in these tests); various adjustments are made against possible biases. External tracking systems are used for this.

The most prominent result aligning with the hypothesis – Aglioti et al. (1995) – found that there was less effect of the illusion on grasping versus with perception. It is this work that is primarily responded to by the following two papers.

Grasping Visual Illusions: No Evidence for a Dissociation Between Perception and Action (Franz et al., 2000)

They first noted some methodological issues with the Aglioti experiments:

1. The experiment was setup such that both visual stimuli were given side by side. This, they claim, increases time taken for visual perception, whereas with grasping the subject is only observing and acting on a single stimulus – to give a name to it, the tasks were not cognitively balanced.
2. To justify giving visual stimuli side by side, the work had made an assumption that "the perceptual effects of the two Ebbinghaus figures simply add up to yield the effect obtained by the direct comparison." This had not been tested.

To test the above, three experiments were set up:

Experimental setup 1:

A similar overall setup to Aglioti's work was taken, with the key difference being that only one of the stimuli was available to the subject at a time (in sequence) for 825 ms. The results were contradictory to the Goodale hypothesis – the mean effect of illusion applied almost equally to both grasping and perception tasks. In addition, subjects showing large perceptual illusion also showed large motor illusion.

To explain the contradiction in results with earlier work, they suggested that the assumption being made on the validity of the "additive effect" – that the effect with direct comparison would merely be the sum of the effects with separate comparisons – was not true. Experiments 2 and 3 were setup to verify this.

Experimental setups 2 and 3:

For experiment 2, the perceptual setup was repeated, only this time with three variations: first with the experimental setup used in Experiment 1, then with the setup by Aglioti et al. (1995), and then

with a third setup they had proposed to simulate the grasping task of the original studies. Results demonstrated exactly the goal of the experiment – that *the perceptual effect of direct comparison was more than the sum of the effects taken individually, and so the assumption of the additive effect was a failure of the original study.*

Experiment 3 was setup to counter a possible argument: that the original setup had subjects compare the two disks immediately before grasping. This setup was replicated by requiring participants to first compare the central circles directly before the comparison to an isolated circle. In theory, this simulates the grasping task imbalance of the original experiment, so if additivity is a property of such then it should be demonstrated here too. Results, again, indicated otherwise – direct comparison was greater than the sum of separate comparisons.

Action does not resist visual illusion (Franz, 2001)

The work looked at a number of studies on the matter of perception vs action. Recent work (for 2001) generally tended to agree that there were "significant effects of visual illusions on grasping," others showed effects that are "close to being significant" but weren't actually there, and one paper showed a reversed effect – a negative impact of visual illusions on grasping. Franz argues that if grasping did resist visual illusions (aka if Action and Perception did indeed have separate visual pathways), then there would be more reversed, or non-significant effects, and fewer results that agreed that there was a significant effect of illusions on grasping.

The studies were generally classified into three classes:

1. Studies that used standard perceptual measures and did not task-normalise: such as Aglioti et al. (1995) and others along the same vein. All of these demonstrated either an insignificant impact of illusions on actions, or no impact at all.
2. Studies that used standard perceptual measures and did task-normalise: such as Franz et al. (2000). These identified the perception vs grasping tasks in the former work as a deficiency, and all such work agreed that visual illusions did have a significant impact on actions.
3. Studies that did not use standard perceptual measures: these have a few problems, all of them stemming from the non-standard perceptual measures used. First of all, "it is unclear whether these measures can be interpreted as perceptual measures." Secondly, the measures yield inconsistent results – to the point where Franz has disregarded the results of all such work.

The paper also responds to some general arguments for the existence of separate processing streams (in the context of the illusion-perception-action tasks).

1. Some suggested that the correlation may be due to *partial* involvement of the perceptual stream in motor functions. This argument is discarded on grounds of methodological problems, as it is now assuming that the motor system is less affected by visual illusions than perception.
2. Others proposed that there is an independent motor illusion generated. But again, studies along these lines either showed very small significant/non-significant effects, or were using nonstandard measures – and hence discarded.

Gaps and How to extend it

The work is not without its flaws. There remain some gaps in the processes employed by the experimental paper, especially, that could do with some improvement.

1. In the grasping tasks, the central circle is a 3D object while the circles surrounding it are 2D images on a screen. This, as the authors themselves acknowledge, reduces the perceptual effect on the subject of the experiment. They have made measures to counter it – by having the screen

at an angle to try and ensure the viewer sees a consistent image, and reducing the thickness of the central disc to only 5mm. However, this could do with improvements.

Possible addition: instead of having the setup as a physical-computer screen hybrid, we could theoretically replace it with an all-physical setup. This would be rather expensive however, and not easy to quickly prototype with.

2. Experiment 3 in Franz et al. (2000) is sort of hand-wavy – it suggests that it is a reasonable simulation of the grasping setup from Aglioti et al. (1995), but that is just described without explanation – the only one given is that the time difference is similar.

   Possible addition: A more formalised explanation of how exactly the third experiment was a good representation of the grasping task in a visual setting.

3. Carey (2001) suggested that the results meant that the motor system only takes into account a close area around the target, while the perceptual system has to attend to the whole thing. It does not necessarily imply that there is an issue with the assumed additive property.

References

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