Changing minds by tracking eyes: Dynamical systems, gaze and moral decisions

Philip Pärnamets (philip.parnamets@lucs.lu.se)
Petter Johansson (petter.johansson@lucs.lu.se)
Christian Balkenius (christian.balkenius@lucs.lu.se)
Lars Hall (lars.hall@lucs.lu.se)
Lund University Cognitive Science, Lund University, Kungshuset, Lundagård, 222 22, Lund, Sweden
Michael J. Spivey (spivey@ucmerced.edu)
Department of Cognitive Science, University of California, Merced, Merced, CA 95344, USA
Daniel C. Richardson (dcr@eyethink.org)
Cognitive, Perceptual and Brain Sciences, University College London, Gower Street, London, WC1E 6BT, UK

Abstract

Decision making is a dynamic process. Alternatives compete over time, and this competition plays out in sensorimotor processes. This is true not just for perceptual decisions or simple categorisation tasks, but also for moral decisions, which are the outcome of a complex interplay of intuition, emotion and reasoning. In this experiment, we first establish a descriptive and causal link between gaze and moral judgement. We then use eye movements to track the time course of participants' moral decisions and show that by interrupting their decision process based on their gaze position, we are able to influence what they decide. We interpret this as evidence for a dynamical systems view of decision making and argue that our results provide new insights into how judgements are reached and constructed in our embodied minds.

Keywords: Decision making; morality; dynamic systems; eye tracking

Imagine a jury, evenly split over a verdict concerning a murder. One jury member is yet to make her decision, which will decide the fate of the accused. She weighs up her choice, looking between the faces of those who argued for and against conviction, glancing at the evidence and police reports on the table. The foreman clears her throat: the jury must take a vote *now*.

The jury member's decision could be analysed in terms of the evidence that is presented and how it is framed, and many experiments have investigated such factors. But here we are interested in one particular, often overlooked aspect: the *precise* moment of choice, in this case when the foreman cleared her throat. We claim that the precise timing of events like these may have a causal influence over a decision. To make our case, we adopt a perspective viewing decision-making as a fundamentally dynamic process. In the decision process, two, or more, options compete over time until one option reaches a threshold or the process is interrupted and the system is forced to reach a conclusion. Secondly, we present evidence that eye movements can reveal something of this process. Where the jury member looked, moment-by-moment showed what option she was considering. Our novel claim is that by manipulating *when* someone is forced to make a decision, and, hence, knowing *where* they are in their decision trajectory, an influence can be exerted of *what* is decided

Process of moral judgements

Recent research in moral psychology emphasizes how contextual factors influence processes underlying moral judgements, factors such as emotional state (Wheatley & Haidt, 2005), political preferences (Graham, Haidt & Nosek, 2009) and causal structure of the moral problem (Cushman, Young & Hauser, 2006). In particular the interplay between intuitions, emotions and reasoning has been of central concern.

In two of the most influential models in this tradition, Haidt's Social Intuitionist Model (Haidt, 2001) and Greene's Dual Process Model (Greene et al. 2008), moral cognition is viewed as being comprised of a number of modules each dedicated towards processing specific forms of information. These modules then discretely combine their output to produce a moral judgement, however, the computational properties of the system are typically not spelled out nor how strict the modular metaphor is to be interpreted.

Taking a cue from dynamical systems modelling of cognition we propose an alternative to stage-based accounts. We view the processes of making moral judgements as a stochastic system of graded, probabilistic representations, in which a judgement can be understood as a temporary settling of the system around an attractor basin in a decision space (McKinstry, Dale & Spivey, 2008; Spivey, 2007). In this study, we exploit a proposed coupling between cognition and gaze behavior to show the dynamic nature of moral judgements.

Dynamic and embodied minds

Minds can be understood and modelled as complex dynamic systems. The discrete symbol and motor output that characterises language and action according to standard models can be generated by graded, probabilistic processes on a continuous timescale, extending beyond the discrete partitions that our everyday practices impose on our understanding of ourselves (Spivey, 2007; Van Orden,

Holden & Turvey, 2005). There is evidence for the neural plausibility stemming from studies measuring and influencing saccades and saccadic programming in real time (Gold & Shadlen, 2000) as well as the large scale probabilistic nature of neural populations (Pouget, Dayan & Zemel, 2003).

A key element of this dynamic view of mind is the tight coupling between sensorimotor outputs and cognitive processing in general – an embodied view of cognition. This is evidenced, for example, during linguistic processing where persons glance towards phonological competitors while viewing an array of objects, by for example looking towards a candle when hearing 'candy' (Tanenhaus, Spivey-Knowlton, Eberhardt & Sedivy, 1995) and when two people are engaged in a conversation with each other (Richardson, Dale & Tomlinson, 2009). Eye movements have been shown to closely follow cognition during spatial indexing tasks in adults (Hoover & Richardson, 2008) and infants as young as 6 months old (Richardson & Kirkham, 2004).

Similarly, mouse movements will show curvature towards distracting alternatives indicating competition in categorisation tasks, for example when classifying whales as being fish or mammals, or, analogously with the eye movement result above, when processing linguistic inputs (Freeman, Dale & Farmer, 2011).

Graded representations have also been found in more advanced reasoning tasks. In one study, participants were asked to judge the truth of a number of propositions that were selected to represent various steps of veridicality. For the propositions with intermediate truth values mouse movements would veer longer between answers thus tracking the more arduous cognitive task of assigning a truth value in these trials (McKinstry et al., 2008).

Gaze preference and choice

The link between gaze and decision making has also been investigated by a number of studies investigating preference formation and decisions. In one study participants were asked to choose which of two faces they found more attractive. Their eye movements exhibited a bias towards the about to be chosen alternative, a finding dubbed the gaze cascade effect (Shimojo et al. 2003). The increasing likelihood to gaze towards a preferred alternative has also been demonstrated for participants considering difficult moral dilemmas (Pärnamets, 2008), indicating that gaze could contribute to moral judgements as well.

In addition, the experiment by Shimojo et al. (2003) demonstrated a possibility to bias preference judgements by actively directing gaze towards one face for longer periods of exposure than the alternative. Similar methods have been utilised to bias consumer decisions for candy bars (Armel, Beaumel & Rangel, 2008). In all these experiments, however, different information is being presented to participants by artificially directing their gaze towards different alternatives.

By contrast, we propose in our experiments that choice can be influenced by manipulating only the timing of the decision and not the stimuli the participant attends to.

Hypothesis

We investigated whether the coupling between eye movements and cognitive processes could be leveraged to influence the discrete end-state of the dynamic process.

We hypothesised, as suggested by pilot experiments from our lab (Richardson, Spivey & Hoover, 2009), that the direction of participants' gaze could be an index of which attractor basin in their decision space they are gravitating towards. Using this information we would be able to collapse their decision function and bias their judgement to the currently favoured alternative, even if that alternative might not have been the option they *would* have preferred, had the decision process been allowed to take its non-interrupted course.

Experiments

We devised a series of experiments that attempted to bias participants' decisions by monitoring their gaze. The first experiment, comprised of two studies (1a and 1b), was designed with a view of establishing an upper bound for our expected effect as well as exploring the link between gaze, as an index of thought, and judgement necessary for our paradigm to work. The second experiment replicates findings for face preference and consumer decisions by manipulating direction and duration of gaze and allows us to establish a causal link between gaze and choice for moral judgements.

The third experiment is our main study which demonstrates the hypothesised effect; influencing decisions solely on the basis of timing. Experiment 4 addresses a possible objection to our procedure and replicates our main finding.

Equipment and materials

Eye tracking was performed using an SMI RED 250 eye tracker running at 250 Hz on a 19" screen with a resolution of 1680*1050 pixels. Stimuli were presented using PsychoPhysics Toolbox (Kleiner, Brainard & Pelli, 2007) running on MatLab 2010b (The MathWorks, Natick, MA.). Gaze was sampled by the MatLab script with 10ms intervals. Calibration was performed on each subject at the start of the experiment using 5 points followed by 4 validation points. Calibrations with error exceeding 1° visual angle in more than one case were rerun. Average error was less than 0.5°.

There were a total of 98 items that participants were asked to listen to and make judgements about. Of these, 63 were moral items and 35 were factual items. The factual items were used previously in our pilot studies (Richardson et al., 2009) and were all propositions that have an average 50% truth value, meaning that a large sample of persons were found equally likely to judge the propositions as being true

or false. An example proposition would be "Is coffee bad for your health?" with the alternatives "Yes" and "No".

The moral items were derived from Moral Foundations Theory (MFT, Graham et al., 2009) and propositions were designed to fit with each of the five categories found in MFT. In addition a few propositions were of a meta-ethical character. An example item is "Murder is sometimes justifiable" with the alternatives "Sometimes justifiable" and "Never justifiable". The alternatives were such that it would be informative to view both for the participant.

General Procedure

Participants were asked to sit in front of a computer screen wearing a pair of headphones. They were instructed that during each trial they would hear a sentence stating either a moral or a factual proposition. Two alternatives would then be shown on the screen, one on the left-hand side of the screen and the other on the right-hand. Their task was to use their judgement to select the alternative that they thought was right in relation to the sentence they heard.

Participants indicated their selection by clicking the right or left mouse button, where the buttons corresponded to the alternatives presented on either the right or left side of the screen. The alternatives were visible for a maximum of 3000ms, or until the experimental 'trigger' went off. This trigger, based on their eye movements, varied between experiments as explained below. The participants then saw a prompt asking them to "Choose now!" Participants were instructed to respond quickly once the prompt was shown on the screen. After each trial, a 1-7 continuous confidence scale was also presented.

Participants were told that the alternatives would be visible for a random and short amount of time each trial and were asked to view both alternatives. Unbeknownst to the participants the timing of each trial was dependent on their eye movements which were being concurrently recorded. The experimental trigger determining the length of each trial was based on the input from the eye tracker during each trial. It was sent to go off as soon one of the alternatives had accumulated at least 750ms of dwell time and the other alternative had accumulated at least 250ms of dwell time. These criteria ensured that the trigger would not go off until both alternatives had been seen by the participant. The exact conditions governing the trigger varied between the experiments and are detailed below.

If participants did not set off the trigger then the trial would time out after 3000ms, and the participants would then be asked to make a choice. Trials timed out either because the participants failed to look at both alternatives, or because the eye-tracker momentarily lost track of the participants' gaze and so failed to capture when the participants shifted their focus between the two choice options. In both cases, there is no way for us using this paradigm to interrupt a decision process where participants are drawn between two competing alternatives. All such time-out trials were removed from further analysis.

Participants indicated during debrief that they occasionally would fail to understand an item and in those cases typically indicated very low confidence following that trial. Trials with confidence <1.5 of 7 were removed for that reason.

Experiment 1a

Procedure In this first experiment we wanted to establish that the coupling between eye movements and cognition would be present even for our moral items. We did not attempt to bias participants' decisions at this point. We simply wanted to show that there is a relationship between the distribution of gaze across two alternatives, and which alternative is eventually chosen. This also allows us to establish an upper bound for the effect size of our later attempts at influencing decisions.

In each trial of this experiment the first 300ms of viewing time were not counted towards the trigger, giving participants some extra time to orient themselves during each trial. From 300ms onwards, we kept track of how long the participant looked at each alternative. As soon as one alternative was viewed for at least 750ms and the other for 250ms, the trigger was set off. We termed the alternative that had been looked at the longest the target. A success was counted if that alternative was chosen, otherwise a failure.

Fifteen persons (11 female) participated in this experiment with a mean age of 20.80 (SD=2.04). Participants were recruited through both the public and student-based subject pools at University College London.

Results and Discussion For the moral items 603 trials (67.67%) were successful ($p<0.0001$, Binomial test). For the factual items 280 trials (65.57%) were successful ($p<0.0001$, Binomial test) (see figure 1).

This version demonstrates the plausibility of using gaze as an index of mental trajectories and using this information to collapse decision space towards an alternative under consideration. We used a 300ms wait time in order to follow the procedure of our pilot work (Richardson et al. 2009). But these early eye movements could presumably also contribute to the decision vector. We therefore ran a second version of the experiment without the 300ms wait time to investigate this.

Experiment 1b

Procedure This Experiment was identical to 1a above, apart from we did not use a 300ms wait time before eye movements to both alternatives were measured. Twenty persons (10 female) were recruited through both the public and student-based subject pools at University College London. Participants had a mean age of 27.20 (SD=8.07).

Results and discussion For the moral items, 716 trials (60.02%) were successful ($p<0.0001$, Binomial test). For the factual items 385 trials (68.14%) were successful ($p<0.0001$, Binomial test) (see figure 1).

From Experiments 1a and 1b we conclude that eye movements are closely linked to the decision making process. If we actively interrupt participants during their deliberation, they are more likely to choose the alternative they have looked at for longer, even for complex moral judgements. We cannot yet claim the causal connexion between the timing of our interruption and the content of the judgement, of course. However, these experiments allow us to establish an upper bound for an expected effect size for the later experiments in which we attempt to bias their decisions in a predetermined manner.

Experiment 2

In experiment 2 we wanted to establish the causal connexion between gaze and choice for the judgements which we were interested in. We adopted the methods used by, for example, Shimojo et al. (2003), where the combination of gaze and exposure, but not exposure alone, had been shown to influence choice. We constructed an experiment where we would be directing participants' gaze towards alternatives so that they would be more exposed to the target alternative compared to the non-target.

Procedure. The procedure in Experiment 2 differs significantly from the general procedure of the other experiments reported here.

Once participants had heard the item, they were presented with one alternative at a time with each presentation lasting 400ms. One alternative was always shown on the right-hand side and the other on the left-hand side. The different alternatives appeared pseudo-randomly, such that the target alternative was given a 3:1 exposure weighting. Total combined viewing time for both the alternatives was 3200ms. Target and non-target alternatives were presented in random order. Choice was indicated after the presentation sequence had completed, as in Experiment 1. Nineteen persons (13 female, mean age 22.36, SD=3.82) participated in Experiment 2. Participants were recruited through both the public and student-based subject pools at University College London.

Results and discussion For the moral items 600 (53.29%) trials were successful ($p<0.05$, Binomial test), while 287 (54.99%) trials were successful for the factual items ($p<0.05$, Binomial test) (see figure 1).

We conclude that there is a causal connexion between gaze and choice. In addition, we demonstrate the possibility to bias moral and factual judgements with the help of directed gaze and exposure effects, and this on the relatively small time scales that our paradigm is operating on. Typical trials in the literature using this method usually last around twice as long as ours.

Additionally, to our knowledge, this is the first empirical demonstration of this effect for moral judgements, and as such, it is a remarkable finding in itself.

Experiment 3

Our goal in this experiment was to exert an influence over the decisions that participants made by manipulating nothing but the timing of their decisions. On each trial, we randomly determined which alternative we would try to bias the participant towards. Unlike in previous experiments that have biased decisions by changing stimuli or directing gaze, including our Experiment 2, our participants looked freely at the alternatives in front of them. We simply tracked the time course of their eye movements during the decision process, and prompted the participants to decide when we judged that their gaze suggested they were at a particular point in their decision space that favoured the option we were trying to influence them to choose.

Procedure Experiment 3 was identical to experiment 1b in all respects except that here the experiment program would, for each trial, randomly designate one alternative as the target. The trigger would only go off if that target alternative had accumulated at least 750ms of dwell time and the other, non-target, alternative had accumulated at least 250ms of dwell time.

Twenty persons (14 female, mean age 29.60, SD=13.14) participated in experiment 3. Participants were recruited through both the public and student-based subject pools at University College London.

Results and discussion For the moral items 609 (58.22%) trials were successful ($p<0.0001$, Binomial test). For the factual items 282 (56.51%) of trials were successful ($p<0.005$, Binomial test) (see figure 1).

This finding demonstrates that we are able to influence participants' judgements in both moral and factual decisions by tracking their gaze alone. We merely asked them to respond at a given point in time when their eye movements reveal them being in a position in their decision space that indicates them gravitating towards a given alternative. We claim that this finding supports our view of the dynamic nature of judgements, where judgements can be understood as trajectories in decision space travelling between alternatives conceived of as attractor basins in that space.

We also wish to highlight the difference between this experiment, where participants are using their gaze actively and are unconstrained in the environment, and Experiment 2 where participants, while moving their eyes, are passive recipients of information. Given this difference and the fact that our paradigm allows varying degrees of relative exposure to the alternatives, in virtue of how the trigger is set up, we argue that our finding in Experiment 3 represents a novel connexion between gaze and choice.

Experiment 4

One possible objection to our claims is that perhaps participants have already made their decisions well before the trigger is set off. It is conceivable that participants gaze towards the target for longer than 750ms, settle on that alternative, and then simply avert their gaze towards the

other alternative out of boredom, which sets off the trigger. Participants then choose the designated target, and the trial is counted as a success. But, the objection goes, if they were allowed to indicate their choice as soon as they'd made it, they would have clicked much earlier in the trial. Experiment 4 was designed to meet this objection by removing the constraint that participants are unable to respond before the prompt screen.

Also, in addition to confidence ratings two extra follow-up questions were asked of participants after each trial. One concerned asked if they had been able to hear the items and see the alternatives properly. The second concerned asked how important the issue raised by the item was to them, which pertained primarily to the moral items. The two additions were made to meet to further objections to experiment 2, namely that participants would only be biased towards our target on items they felt were unimportant or where they failed to fully understand the item or alternative. These were also set in terms of 1-7 continuous scale.

Procedure The trigger was set up to work as in experiment 2. In addition, time participants were instructed that they could also indicate their choice when they had made up their minds, clicking the mouse in the same way as they would during the 'Choose now!' screen.

21 persons (17 female, mean age 21.81, SD=5.38) participated in experiment 3. Participants were recruited through both the public and student-based subject pools at University College London.

Results and discussion For the moral items 240 (21.27%) trials were such that the participant responded before the experimental trigger was activated. The corresponding number for the factual trials was 264 (45.28%). Since these are cases where the trigger has not been activated, these trials were not analysed further.

Of the remaining trials 496 (55.86%) were successful ($p<0.001$, Binomial test) for the moral items, and for the factual items 189 (59.24%) trials were successful ($p<0.005$, Binomial test) (see figure 1). Analysing the various ratings participants made after their decision, we found that there were no significant difference between trials that were successfully biased and those that were not. For moral items, there was no difference in comprehension between successful trials (M=6.57) and unsuccessful trials (M=6.50) ($t(809.223) = 1.67$, $p=0.09$); and no difference in perceived importance on successful trials (M=4.98) and unsuccessful trials (M=4.92) ($t(847.692) = 0.57$, $p=0.57$). Similarly, for factual items there was no difference in comprehension between successful trials (M=6.55) and unsuccessful trials (M=6.52) ($t(262.72) = 0.261$, $p=0.79$); and no differences in importance ratings either (M=3.53, successful, M=3.35, unsuccessful, $t(268.412)=0.92$, $p=0.36$).

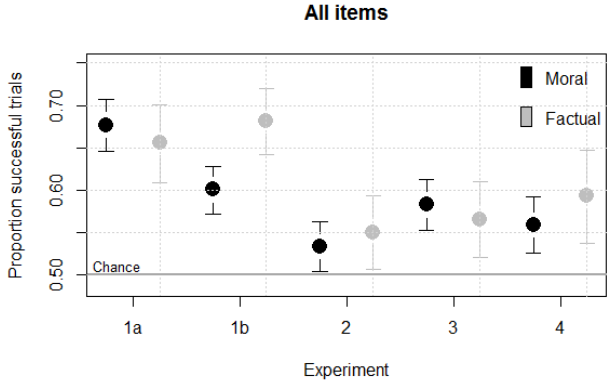

Figure 1: Results from the experiments for all items. 95% confidence intervals are shown.

We find in this experiment that there are trials where participants make up their minds before our manipulation is triggered. But these cases do not explain our findings, since when they are excluded from the analysis, our biasing effect remains. Experiment 4 still demonstrates judgements malleable to influence depending solely on the timing of judgement based on measuring gaze indexed thought trajectories.

General Discussion

We have argued that decision making is a dynamic system exhibiting a tight coupling between eye-movements and judgement. We have demonstrated a causal link between gaze and choice using a paradigm utilising exposure and directed gaze. We then, following the logic of dynamical systems, have shown that we are able to influence participants' moral and factual judgements using gaze only as an index of thought, and by manipulating nothing but the timing of the decisions. The results from Experiment 4 suggest that our effects are no mere artefacts of the experimental procedure.

A surprising aspect of our results is the demonstration of the malleability of moral judgments on very small timescales across the wide spectrum of moral domains which our stimuli encompass. This malleability is present even when we manipulate only the timing of decisions, rather than by adding information to the situation, as has typically been the case in the literature. We emphasise that while we interpret our findings in the light of a dynamical systems perspective on mind, the effects on moral judgements are of significant interest by themselves for understanding our moral mind.

One valid concern about our findings is the relatively small effects sizes. This is not too surprising, however, due to the fact that gaze and decision making processes, while linked, cannot be not rigidly yoked together. For one thing, eye movements have various biological constraints and are necessarily discrete, whereas thought processes could be continuous and graded; for another, one can chose between options while fixating a single point. Given the partial - though pervasive (Spivey, Richardson & Dale, 2009) - link between eye movements and cognition, it is not surprising that gaze is an imperfect indicator of decision processes, and our bias effects are the size that they are. Indeed, we would argue that it is remarkable that they exist at all.

A significantly higher effect size would be surprising for other reasons as well. One reason is that this would jar with our capacity to, at times, be moral agents. Recall, we are not making a claim about a possible lack of moral agency in our participants, only a claim about morality's dynamic nature. In a sense the size of our effect says something very real about the strength of our participants' moral systems. It opens up avenues for a more detailed exploration of individuals' and groups' moral landscapes, as well as understanding the complex interplay between cognition, sensorimotor systems and the environment.

In future work we hope to expand the range of moral decisions under examination, and develop computational models of the process. The class of judgements we have used here are first person judgements about one's personal moral values. These are judgements which are known to be open to manipulation (Hall, Johansson & Strandberg, 2012). In further research we plan to extend our results to third person judgements and concrete moral action. Eventually, we hope to model the dynamics of moral decision marking. Drawing on our current findings, we aim to develop a model that exhibits the same drift towards attractor states when interrupted as we found in our participants and compare this to alternative accounts such as drift-diffusion and accumulator models. But from the results we have presented here, we hope the case has been made that that much can be learned about our moral selves by focusing on the deep integration between cognitive and perceptual functions and how this integration plays out in time.

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References

Armel, K.C., Beaumel, A. & Rangel, A. (2008) Biasing simple choice by manipulating relative visual attention. *Judgment and Decision Making*. 3(5), 296-403.

Cushman, F.,Young, L. & Hauser, M. (2006) The role of conscious reasoning and intuition in moral judgment. *Psychological Science*, 17(12), 1082-1089.

Freeman, J.B., Dale, R. & Farmer, T.A. (2011) Hand in motion reveals mind in motion. *Frontiers in Psychology*. 2, 59.

Gold, J.I. & Shadlen, M.N. (2000) Representation of a perceptual decision in developing occulomotor commands. *Nature*. 404, 390-394.

Graham, J., Haidt, J. & Nosek, B.A. (2009) Liberals and conservatives rely on different sets of moral foundations. *Personality Processes and Individual Differences*. 96(5), 1029-1046.

Greene, J.D., Morelli, S.A., Lowenberg, K., Nystrom, L.E. & Cohen, J.D. (2008) Cognitive load selectively interferes with utilitarian moral judgment. *Cognition*. 107, 1144-1154.

Haidt, J. (2001) The emotional dog and its rational tail. *Psychological Review*. 108(4), 814-834.

Hall, L., Johansson, P. & Strandberg, T. (2012) Lifting the veil of morality: Choice blindness and attitude reversals on a self-transforming survey. *PLOS One*. 7(9), e45457

Hoover, M. A. & Richardson, D. C. (2008). When Facts Go Down the Rabbit Hole: Contrasting Features and Objecthood as Indexes to Memory. *Cognition,* 108(2), 533-42

Kleiner, M., Brainard, D. & Pelli, D. (2007) What is new in Psychtoolbox-3? *Perception 36 ECVP Abstract Supplement.*

McKinstry, C., Dale, R. & Spivey, M.J. (2008) Action dynamics reveal parallel competition in decision making. *Psychological Science*. 19(1), 22-24.

Pouget, A., Dayan, P. & Zemel, R.S. (2003) Inference and computation with population codes. *Annual Review of Neuroscience*. 26, 381-400.

Pärnamets, P. (2008) *Perceptual components in moral decision making*. Unpublished master's thesis. Lund University, Lund, Sweden.

Richardson, D.C., Dale, R. & Tomlinson Jr, J.M. (2009) Conversation, gaze coordination and beliefs about visual context. *Cognitive Science,* 33, 1468-1482.

Richardson, D.C & Kirkham, N.Z (2004) Multimodal events and moving locations: Eye movements of adults and 6-months-olds reveal dynamic spatial indexing. *Journal of Experimental Psychology: General*, 133(1), 46-62.

Richardson, D.C, Spivey, M.J., & Hoover, M.A. (2009) How to influence choice by monitoring gaze. In N.A. Taatgen & H. van Rijn (Eds.), *Proceedings of the 31th Annual Conference of the Cognitive Science Society. Austin, TX: Cognitive Science Society*.

Tanenhaus, M.K., Spivey-Knowlton, M.J., Eberhardt, K.M. & Sedivy, J.C. (1995) Integration of visual and linguistic information in spoken language comprehension. *Science*. 268(5217), 1632-1634.

Shimojo, S., Simion, C., Shimojo, E. & Scheier, C. (2003). Gaze bias both reflects and influences preferences. *Nature Neuroscience*, 6(12), 1317-1322.

Spivey, M.J. (2007*). The continuity of mind*. New York, Oxford University Press.

Spivey, M.J, Richardson, D.C, & Dale, R. (2009). The movement of eye and hand as a window into language and cognition. In E. Morsella, J. A. Bargh, & P. M. Gollwitzer (Eds.), *Oxford Handbook of Human Action* (pp. 225–249). New York: Oxford University Press.

Van Orden, G.C., Holden, J.G. & Turvey, M.T. (2005) Human cognition and 1/f scaling. *Journal of Experimental Psychology: General*. 134(1), 117-123.

Wheatley, T. & Haidt, J. (2005) Hypnotic disgust makes moral judgements more severe. *Psychological Science*, 16(10), 780-784.