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Change of Intention in 'Picking' Situations

Ariel Furstenberg, Leon Y. Deouell, Haim Sompolinsky

Introduction

In a typical Libet-style experiment the task includes selecting between options which are on a par for the participant, for instance, pressing a right or left button according to what the participant 'freely wants' when a cue appears. Following the distinction set forth by Ullmann-Margalit and Morgenbesser (1977), this type of selection between options that make no difference to the subject is termed 'picking' and is distinguished from 'choosing' in which there is a reason for the selection of one of the alternative. In our paper we focus at first on *picking* type selections and investigate the mechanism which underlies the selection process in *picking* scenarios, making the selection possible at all.

As early as Aristotle, the question has arisen as to the possibility of making an active selection of one alternative out of a set of indifferent alternatives; whether the selecting agent is human, non-human or God himself.[1] Aristotle claims that a "man who is violently but equally hungry and thirsty, and stands at an equal distance from food and drink … must remain where he is."[2] This claim is elaborated by Aquinas: "If two things are absolutely equal, man is not moved to one more than to the other; thus, if a hungry man … be confronted on either side with two portions of food equally appetizing and at an equal distance, he is not moved towards one more than to the other."[3] And later on, by Spinoza: "if a man were placed in such a state of equilibrium he would perish of hunger and thirst, supposing he perceived nothing but hunger and thirst, and the food and drink were equidistant from him."[4] Leibniz continues this line of thought and emphasizes the lack of a differentiating reason or cause[5] in these indifferent situations: "In absolutely indifferent things there is no choice at all and consequently no election or will, since choice must be founded on some reason or principle."[6] Newton disagrees. His disagreement is expressed in Clarke's reply to Leibniz, which is taken to be in the name of Newton:

> [He, Leibniz, supposes] that motives have the same relation to the will of an intelligent agent as weights have to a balance, so that, of two things absolutely indifferent, an intelligent agent can no more choose either than a balance can move itself when the weights on both sides are equal. But the difference lies here. A balance is no agent but is merely passive and acted on by the weights, so that, when the weights are equal, there is nothing to move it. But intelligent beings are agents—not passive, in being moved by motives as a balance is by weights—but they have active powers and do move themselves, sometimes on the view of strong motives, sometimes on weak ones, *and sometimes where things are absolutely indifferent*. In this latter case, there may be very good reason to act, though two or more ways of acting may be absolutely indifferent. (Clarke's fourth reply to Leibniz, §§1-2; my emphasis)

For Newton, as long as there is a reason to act rather than not-acting, the agent will have the power to make a selection even "*where things are absolutely indifferent*". Leibniz rejects this stance and claims that it is a mere contradiction (Leibniz's fifth letter, §16). However, he claims that "we are never indifferent, even when we appear to be most so, as for instance over whether to turn left or right at the end of a lane. For the choice that we make arises from these *insensible stimuli*…"[7] These '*insensible stimuli*' are equated elsewhere to the "conjunction of *minute perceptions*"; and these "*insensible impressions*… can suffice to tilt the balance."[8]

Let's go a step further with Leibniz's idea of 'tilting the balance'. A basic approach for the selection process in picking situations is that although on a basic cognitive level there is symmetry between the alternatives, on a lower causal level the symmetry does not maintain. We term this transition from the cognitive level to the causal level – 'symmetry breaking'.[9] This symmetry-breaking between alternatives is what makes possible the picking of one alternative rather than the other; if the symmetry were maintained throughout all levels, picking would be impossible. However, the question arises as to the nature of the asymmetry of the lower causal level and how is it produced.

In this paper we confront this issue by concentrating on *proximal intentions* within a *picking* scenario. Intending to do something *now*, in contrast to long term commitments and intentions, is considered a proximal intention. It is a rapid procedure of settling on an action and executing it. Since proximal intentions are closely connected to the process of *executing* a plan to act, the possibility of *unconscious* proximal intentions arises, like in the case of a driver signaling for a turn, as exemplified by Alfred Mele (2009). Thus, proximal intentions are defined here as a conscious or non-conscious preparation, or build up, towards a specific act.[10] In order to obtain within a *picking* task a neuronal symmetry-breaking scenario which can be exposed through an electrophysiological signal, we used a masked priming paradigm while recording EEG. This revealed, among other things, a 'change of intention' phenomenon as part of the *picking* selection process.

In what follows, we first present the concepts of *picking* vs. *choosing* and the idea of a causal symmetry breaking event as the basic mechanism for picking. Thereafter, we present our 'change of intention' experimental results which, as we shall see, challenge the non-dynamical symmetry breaking event mechanism which was offered by others, and calls into question the principled difference between *picking* and *choosing*. In order to explain our results we propose at the next stage a *dynamical* model for such *picking* scenarios, which we claim to be even more general, including *choosing* scenarios as well.

Picking vs. choosing: causes and reasons

Picking scenarios come in many forms and shapes. The most basic form is when one is indifferent with regard to the alternatives.[11] Consider for example a common supermarket shopping experience: one finds himself standing in front of stacks and stacks of, say, tuna cans of the same brand, size, weight, color etc. In order to select a can of tuna one has to perform a picking selection task. By definition, in a picking selection task there are no *reasons* for selecting a particular alternative. However, another picking scenario type is one in which the alternatives *do* make a difference and one has good reasons for preferring one alternative over the other, yet the alternatives are presented to the agent as externally identical; for example, two visually identical boxes, one empty and the other contains $1000, and the agent is aware of these facts. The alternatives are definitely not identical, but one has no *reason* for selecting one box over the alternative. Thus, this is also a picking situation.

In contrast to picking scenarios, a *choosing* scenario is one in which an agent -- given the context, one's self identity, things one cares about etc.[12] -- has a (reasoned) preference of one alternative over the other. “Thus one normally chooses rather than picks a spouse, a child’s name, a dwelling house, a piece of jewelry, an employee, etc.”[13] Note however that a specific case isn’t defined objectively as a picking or a choosing case; it depends on the context and the personality of the agent. Thus, what is in a given context a picking situation for one agent can be a choosing situation for another and vice versa. Of course, we have in mind paradigmatic cases for each of the picking and choosing categories, but also they might be relativized according to context and human character.[14]

Conceptually, we differentiate between *causes* of action and *reasons* for action. Without going deeply into these notions we can say that *causes* are part of the lower level causal framework, whereas *reasons* are part of a higher normative and conceptual level framework (termed also ‘the space of reasons’[15]). Since a *choosing* scenario is one in which an agent has a reasoned preference of one alternative over the other, this reasoned preference is expressed as (or translated into) a link within the causal chain which physically selects the chosen alternative.[16] Thus the asymmetry between the alternatives within a *choosing* scenario goes all the way down from the *reasons* for action to the *causes* of action. On the other hand, in a picking scenario in which by definition there is no reasoned preference of one alternative over the other, how is picking possible at all?

Descriptively, on a cognitive (‘space of reasons’) level: there are genuine *picking* situations which are not rare at all in our modern day environment (supermarkets for example), and one has no *reason* for selecting one alternative over the other. Nevertheless, we know that one has the ability to pick. As mentioned above, a basic approach for the selection process in picking situations is that although on a cognitive level there is symmetry between the alternatives, on a lower causal level the symmetry does not maintain. A few suggestions have been proposed (which do not eliminate each other) explaining this asymmetry[17]: one option is that the asymmetry between the alternatives on the causal level is a result of *external* subliminal causal differences. Subliminal differences are "indeed capable of 'tempting' and 'drawing' you toward just one of the alternatives before you".[18]

Another option might be that one is transformed into a chance device that functions at random and effects arbitrary selection.[19] This can come about by a noisy causal mechanism. The result of this is that there is never actually a perfect symmetry between alternatives standing for selection. The level at which one is transformed into a random selection device is on a *causal level*, although we do not mean a metaphysically random device as would be referred to by a quantum-mechanics device, only from an epistemic perspective; "much like saying that while the course of a tossed die may be completely physically determined, for us it nevertheless functions as a chance device due perhaps to irremediable human ignorance of initial conditions".[20] C*hoosing* is different than *picking*; in *choosing* there is no symmetry on the cognitive reason-wise level between the alternatives, therefore on the causal level there definitely is no symmetry, and there is no room for any symmetry breaking mechanism as, for example, the random selection mechanism.

In *picking,* the alternatives make no difference and we just need a simple mechanism that would make the selection; a common metaphor is that of a discrete random event such as 'coin tossing'.[21] Of course under this metaphor there would be no need for "change of mind" or regret. For example: "Often enough, or perhaps typically, what occurs in a selection situation you identify as a picking one is that you haphazardly focus your *attention* on some one of the available alternatives. Once you do that, however, then – by hypothesis – none of the other alternatives attracts you more, and there is no room for qualms or second thoughts. So, given the absence of either detracting or distracting factors, there is nothing to prevent you from going ahead and grabbing (or doing) that focused-on alternative" and there is no room for *regret*.[22] This *discrete symmetry-breaking event* is what determines which alternative is selected. However, the picture is more complex. As we shall claim the *'coin tossing' metaphor* does not do the 'work'. In what follows we want to question the simple discrete, non-dynamical, conception of a causal symmetry-breaking event as the *picking* decision mechanism and cast doubt on the principled difference between *picking* and *choosing*. This is complemented by a critique on the notions of 'decision' and 'execution' commonly used with regard to decision making.

Change of intention: empirical results

In this section we present in a general manner the paradigm and the main results which highlight the mechanism involved in acting within a picking selection task.[23] In order to obtain within a picking task a causal symmetry-breaking scenario which can be exposed through an electro-physiological signal, we used a masked priming paradigm while recording EEG; searching especially after forms of 'change' in the direction of the causal 'build up' for hand movement. Masked primes are stimuli presented very briefly, rendered *invisible* by an immediately ensuing masking stimulus, nevertheless effecting behavior.

The experiment took place in a dark, sound attenuated chamber in which participants comfortably sat in front of a monitor. Each trial began with the presentation of a brief prime followed by a mask, which was followed by a cue. Prime stimuli included right or left arrows (">>" or "<<") or both (<<>>; a neutral stimulus), presented at the center of the screen. The mask was constructed of lines of various lengths and orientation scattered on a rectangle at the center of the screen (see Figure 1**)**. There were two types of trials (presented hundreds of times), each consisting of a masked prime followed by a cue. In both types, the prime could be directional (left or right arrow) or neutral: (1) in *instructed* trials the cue was a left (<<) or right (>>) arrow cue, and the task was to press the right or left button quickly and accurately according to the instructing arrow cue. (2) In *free-choice* trials the cue was a plus sign (+) and the task was to press rapidly left or right according to *whatever the participant wants* at the moment of the cue. The participants were urged not to pre-plan or construct a strategy regarding which button to press. The participants were not informed of the existence of the prime. Thus they were explicitly aware only of the screen with random lines which preceded the instructing or free-choice cue. Instructed (left or right) and free-choice trials were randomly intermixed.

[INSERT FIGURE 1 HERE].

Following the main testing session, *awareness of the primes* was tested in an objective 2-interval 2-alternative-forced-choice detection test block. Participants were categorized as 'aware of the prime' if their performance in this task was significantly above chance level. Note that when we talk of a non-conscious process we refer to a process which does not reach *report-level consciousness*; however, the exact link between consciousness and reportability is a matter of dispute (Block 2007; Mele 2009: ch. 2; O'Shaughnessy 2008: 360-362).

During the main testing session EEG was recorded continuously from scalp electrodes. Previous studies have used EEG to follow the evolution of the Lateralized Readiness Potential (LRP), as a measure of motor preparation. The LRP is derived by subtracting the pre-response potential recorded from the scalp over one hemispheric motor cortex, from the potential recorded similarly on the contralateral scalp. Since activity (indicated by EEG negativity) over the motor cortex contralateral to the moving hand is higher than over the ipsilateral motor cortex, the polarity of the result indicates the hand which is prepared to move. For example, by subtracting the activity on the right hemisphere from that on the left hemisphere, a right hand movement should be observed as a negative signal deflection, while a left hand movement should be observed as a positive deflection. LRP's are usually obtained while time-locking the signal average to the response. However, in this case information that is stimulus dependant, as in our case, could be obscured in the response-locked average due to stimulus-response time jitter. Thus, since we are interested in the priming stimulus effect we calculated the stimulus locked average (e.g., Eimer and Schlaghecken, 1998; Kiesel et al., 2006).

Although most participants were unaware (according to the awareness test) of the presence of the masked prime, and even when we limited the analysis only to those participants who were not aware of the prime, we observed a behavioral effect of the prime**:** on *instructed* trials performance was slower and participants had more errors when the prime and instruction cue pointed in different directions (i.e., incongruent trials), than on congruent trials; on *free-choice* trials performance was slower in the incongruent cases (i.e., prime and response in different directions), and primes significantly biased freely chosen responses in the direction of the prime. At the electrophysiological level, we revealed a spatio-temporal LRP signal around 250-350ms after prime onset which we interpret as an EEG signal induced by the prime, representing preparation to move right or left according to the prime cue direction. This signature allowed us to explain the behavior cost of incongruence, both in *instructed* as well as in *free-choice* trials, by a 'change of intention' scenario: the participant prepares the type of action indicated by the prime but 'changes his/her mind' and actually acts differently. In this experiment, the 'change of intention' is composed of an initial intention prompted exogenously by a masked prime, which is then overruled either by an exogenous instructing arrow in the *instructed* case, or by an endogenous intention in the *free-choice* case (Furstenberg et al., 2012).[24]

In the incongruent condition, whether in the *instructed* or the *free-choice* tasks, the agent is in the process of preparing a motor act in one direction (in other words, the agent has a proximal intention to move in that direction) which is overcome by an intention to move in the other direction. This 'change of intention' structure is expressed behaviorally by longer response times in the incongruent case. Moreover, the prime induced motor cortex activation can be interpreted as the source for more errors (in the *instructed* trials) and bias towards the prime (in the *free-choice* trials). The 'change of intention' interpretation is opposed to other options explaining longer response times as 'hesitation', 'confusion', 'unsettledness'. Our claim is that the conflicting intentions reach out into the motor execution stage and do not express an earlier perceptual stage. Note that participants are not conscious of this non-executed movement preparation; moreover, it seems that they are not conscious of the *change* itself in this 'change of intention' scenario.

If we take the *free-choice* condition as a paradigm for *picking* situations, it seems to pose a problem to the notion of a 'symmetry-breaking *event'* as the central decision mechanism in a picking situation. Our experimental *free-choice* task is a *picking* selection task since participants do not have any reason to prefer one button over the other. Thus one would expect accordingly that an intention (i.e., a preparation) to move a certain hand, induced by the masked prime, would constitute a substantial causal asymmetrical event between the alternatives as to eliminate any *regret* or *second thoughts*. However, in the free-choice incongruent results we observe a neural 'build-up' and preparation to move in a certain direction, caused by the prime, which is *nevertheless* overcome by an alternative intention. Thus the 'symmetry breaking' signal which we observe in our results is not a discrete symmetry-breaking event, but rather extended in duration and with an analog graded character. We refer to such a type of 'symmetry breaking' signal as *dynamical*. These empirical data call into question the hypothesis that *picking* selection cases cannot reasonably include 'change of intention' scenarios. Moreover, this structure makes the *picking* case seem comparable to *choosing* cases and to a *deliberation process*. Thus, as we shall discuss later, maybe the deep (conceptual) dichotomy between these two types of selection processes, *picking* and *choosing*, does not hold from a psychological-neuronal perspective.

Our results reveal that 'change of intention' is observed not only in the central nervous system, but also in peripheral muscle activation measured with electromyographic (EMG) electrodes placed over the forearm muscles flexing the fingers. Although the non-responding hand muscles showed occasional activity in all type trials, it was significantly more frequent on the *incongruent* trials, both instructed and free-choice, consistent with the direction of the prime. Thus, the primed intention not only activates the motor cortex before it is overcome by the final intention, but goes on to the periphery and activates the muscles, suggesting that the peripheral muscle activity is part of the same 'change of intention' phenomenon, yet an extended one. If with regard to the motor cortex we might have said that we are observing some sort of 'weighing up possibilities' and not a definite decision, can we say the same regarding the muscles?

Modeling the instructed and free-choice tasks

In order to make sense of these results and phenomena we propose a large-scale neural-network model, which accounts and elucidates a possible mechanism for the observed phenomena.[25] Thus we enumerate a few central empirical features we would like our model to account for:

1. The *instructed* congruent and incongruent LRP waveform: an initial signal deflection in the direction indicating the prime direction continued by a deflection indicating the response direction (same direction in the congruent case; opposite directions in the incongruent case).

2. The *free-choice* congruent and incongruent LRP waveform: same form as in the *instructed* case.

3. Behavioral features, such as (a) Response Time (RT) differences between congruent and incongruent conditions in the *instructed* and *free-choice* trials; (b) percent of errors in *instructed* trials; (c) choice bias towards the prime direction in *free-choice* trials.

4. Percentage of non-responding hand activation (EMG) in congruent and incongruent conditions (in *instructed* and *free-choice* trials).

As a point of departure we first adopt the neural-network model by Bowman, Schlaghecken and Eimer (2006) proposed by them in order to explain inhibitory processes within a context of subliminal priming (we will refer to it as the *basic model*). The general structure of the Bowman network is constructed of a few basic layers: perceptual layers (from stimulus presentation to perceptual pathways), motor activation layer,[26] accumulation layer and context maintenance (see figure 2). Their model was intended to give an account for *instructed* condition type trials with masked priming, consisting of an arrow prime (16.667ms), a masking stimulus (100ms) and an arrow target (100ms), all appearing consecutively. The main phenomenon they attempted to model was the Negative Compatibility Effect (NCE). Studies show (Eimer and Schlaghecken, 1998; Schlaghecken and Eimer, 2004; Kiesel et al., 2006; Sumner, 2008) that when prime and target are separated by a short inter-stimulus-interval (short ISI, 0-60ms) performance is facilitated on congruent trials and impaired on incongruent trials, relative to neutral trials (this is termed: Positive Compatibility Effect (PCE)). However, on long inter-stimulus-interval (ISI = 100-200ms) the opposite happens (termed: Negative Compatibility Effect (NCE)): performance benefits are observed on incongruent trials and costs are observed on congruent trials. I.e., in the congruent case response time is delayed relative to the incongruent case; moreover, there is also a selection bias towards the *opposite* direction of the prime (Klapp and Hinkley, 2002; Schlaghecken and Eimer, 2004; Schlaghecken et al., 2009). This suggests an early facilitation and later inhibition of action in the direction indicated by the prime, which was observed in the LRP results obtained by Eimer and Schlaghecken (1998). The Bowman et al. model, intended to capture these results, was basically successful.

[INSERT FIGURE 2 HERE]. [CAPTION: Caption 2 text goes here.]

Indeed, applying this model onto our experimental *instructed* parameters (prime duration = 20ms, mask duration = 40ms, cue duration = 70ms) resulted in our general LRP signal indicating a Positive Compatibility Effect (PCE). On the other hand, there were several central aspects which were not accounted for by this basic model and thus the model required modifications. First of all, the, model does not account for the *free-choice* condition on its various levels: behavioral and LRP. Second, the *instructed* condition is lacking the possibility for errors. Third, the model is limited to the accumulation in the motor activation layer, but gives no account for the muscle activation stage (EMG).

It seems that in order to account for a *free-choice picking* condition as in our experiment we have to add into the network some sort of *continuous random noise*. This random noise would be analogous to a noisy 'inner state' which becomes the source of the left and right evidence when the *free-choice* cue is perceived. Moreover, by adding continuous random noise into the *instructed* condition as well, we might achieve also the proportion of the instructed *error* trials we observe empirically. Therefore we propose to add *random noise* as inputs into the motor activation layer. This noise enters the motor activation layer at a certain level of activity all along, including during the *instructed* condition. However, whenever the *free-choice* cue is perceived in the perception layer, the level of noise is increased, and this increased noisy inner state enters as inputs the motor activation layer.

Since every trial is different as a result of the noise, each trial looks more like an empirical single trial. In order to regain a clearer picture we averaged over many trials, sketched the averaged *free-choice* and *instructed* LRP, calculated the averaged response time (RT), the percent of errors in the *instructed* case, and the bias towards the prime direction in the *free-choice* trials. We revealed a very good fit with our empirical results. The modeled LRP in these cases looked more or less like our empirical results with the waveform in the *incongruent* case deflecting at first in the direction indexing the direction of the prime, and then the deflection changes its course towards the final movement direction. This means that not only can we model the *instructed* trials, including behavioral error rates etc., but furthermore the ‘change of intention’ LRP structure we observed in *free-choice* picking trials can be accounted for very well by adding the *random noise* into the network.

<u>Biases and one’s noisy inner state</u>

Before continuing we should dwell for a moment on the following question: what are we actually measuring with the LRP? The LRP in the model is a measurement of the difference between the left and right motor activation nodes. However it is a measurement preceding the accumulator threshold crossing stage and the supposed moment of decision. If this is the case it seems clear that when we refer to the LRP we are not talking about a ‘change of *decision*’ structure, but only of a ‘change of intention’ structure. Note that ‘intention’ is an appropriate term for this stage, as what is reflected in the LRP is a *preparation* to move in one direction or the other. What we observe is a ‘build-up’ towards the action even if we don’t have yet the final trigger. We see the ‘striving towards’, not the final commitment.[27] Thus we can relate to the LRP as an ‘intention-meter’.[28]

Back to our original question: can we talk about a symmetry breaking *discrete event* (‘coin tossing’) as the central decision mechanism in a *picking* situation? From our empirical ‘change of intention’ results it seems that we can definitely answer ‘no’ to this question. In addition, from the model we suggested it seems that we can offer an alternative mechanism in the form of a *random inner state noise*. Applying the random noisy inner state into our neural-network model and receiving the *dynamical* ‘change of intention’ structure in addition to our behavioral results, proves that this is a sufficient mechanism in explaining the phenomenon of change of intention within a free-choice picking scenario.

Yet, it seems that we can say more than that. The *instructed* trial results are also obtained by adding a certain level of the noisy inner state into the mechanism. Thus, also *instructed* and *free-choice* conditions basically have the same ingredients constructing their decision mechanism: various *biases* and *random noise*.

In a pure picking task (with no prime) there are no evident biases, only one's noisy inner state (which might result among other things from non-evident biases). In our experimental *free-choice* picking task there is basically the bias of the prime direction (as expressed by the initial motor activation) which is followed by the inputs of the noisy inner state. The inner random noise has the ability, as we saw in a large portion of the trials, to overcome the bias caused by the prime (these trials were recognized as the *incongruent* free-choice trials). Moreover, also in the *instructed* condition we observe various biases, such as the prime and the arrow cue, which interact with the noisy inner state. Thus the inner random noise can cause errors even in the face of a conscious arrow cue. The interaction between the *biases* and the *random noise* are essential to the decision mechanism in the *instructed* and *free-choice* conditions. Nonetheless, in picking contexts the agent uses various methods such as amplifying the noise or decreasing the threshold[29] in order to perform an act effectively and to definitely reach a selection (since low amplitude noise might never cross a far-reaching threshold). These are systematic elements that are fitted to types of situations, such as picking ones, perceived by the agent. Thus we can claim that *instructed* and *free-choice* conditions don't essentially differ from each other mechanistically; they both contain *biases* and *random noise* as part of the decision mechanism, they differ only in the type and quantity of biases and the amplitude of the random noise.

Here we want to go a step further and claim that our *instructed* and *free-choice* conditions are on two opposite ends of a *continuum* regarding the 'space of reasons'. Moreover, a typical *proximal choosing* situation falls somewhere in the middle of this scale. In opposition to the *free-choice* condition in which an agent has no motivation and no reason to prefer one alternative over the other, in the *instructed* condition the agent definitely has a strong motivation and a strong reason to choose the instructing arrow direction. It may well be that the *reason* in the *instructed* case is not formed at the moment that the agent perceives the arrow, but at an earlier stage when the agent hears the experimental instructions knowing that if he does not comply with the instructions it might be embarrassing. Nevertheless, the *instructed* condition is a type of a *choosing* scenario, although one with a very clear reason and bias towards one alternative (the hand indicated by the arrow). Therefore it seems reasonable to relate to any *choosing* situation as falling somewhere on the continuum between one end, in which there is no preference or reason for any alternative, and the other end in which there is a strong reason for selecting one alterative. A typical *choosing* situation might exhibit an intermediate character by having various reasons for one alternative and others for the rival alternative.

From this perspective, we can expand our claim above that *instructed* and *free-choice* conditions don't essentially differ from each other mechanistically; we maintain that anything on the continuum between the edges of the *proximal instructed* and *free-choice* conditions does not differ from each other from a neuronal perspective, and expresses an interaction between *biases* and *random noise*. Thus we may conclude that *proximal picking* and *choosing* are basically the same process with various biases interacting with one's noisy inner state. Note that also in a *choosing* situation the *reasons* might not be exhibited to the agent 'online' at the moment of decision, especially in *proximal choosing* situations, such as kicking the car breaks immediately when you observe a ball rolling into the street. The ball rolling into the street is a cue for the reasoned process done earlier and elsewhere in life, expressed as a bias towards kicking the breaks, similar to the instructing arrow in the *instructing* trials.

Ullmann-Margalit and Morgenbesser (1977) point to the fact that young children turn every task into a *choosing* task. Children see meaning in every selection task even if they do not know how to articulate this meaning. Therefore young children trying to select in a *picking* task (say, select a candy from a bag full of identical red candies) change their mind several times in the process of selecting, as if it were a reasoned *choosing* task. However, in the light of the continuum between *picking* and *choosing*, it might just be that children simply present explicitly the process that adults engage in as well in a more subtle way.

Where is the decision?

Since discussions on *picking* and *choosing* and decision making in general stress the aspect of a discrete 'decision' in their mechanism we want to complement our discussion by addressing the widespread metaphor of a decision-making center (brain) which sends execution orders to the periphery (muscles). Is this metaphor a good one? Are all executed intentional acts a result of a *moment of decision*? Decision moments are expressed in models through a decision criterion and a threshold crossing. However, perhaps the common *threshold* model should be replaced by a *continuous* model, though of course one that has the ability to pick and choose in the end.

Many studies on decision-making have assumed a decision criterion with an accumulator threshold crossing model (e.g., Bowman et al., 2006; Bogacz et al., 2007; Michelet et al., 2010; Mattler and Palmer 2012; Schurger et al., 2012), though lately a few studies have made an attempt to go against the existence of a rigid decision moment. This disagreement is a revival of a dispute from the 1970's and 1980's whether the sensory-motor system is best described by a 'continuous signal flow' picture or by a 'serial signal flow' picture (e.g., Grice et al., 1977; Eriksen and Schultz 1979; Coles et al., 1985; Smid et al., 1990; Sternberg 1969). One way of achieving a non-rigid decision moment is by opening the possibility for post decision-moment changes of mind, thus turning the decision moment into a non-final moment, reminiscent of Libet's claims for a decision-followed-by-veto possibility. For example, Shadlen and colleagues (Resulaj et al., 2009) have proposed models for perceptual decision making, following experiments in which participants had to make a decision regarding a noisy visual stimulus, indicating their decision by moving a handle in the appropriate direction. They "propose that noisy evidence is accumulated over time until it reaches a criterion level, or bound, which determines the initial decision, and that the brain exploits information that is in the processing pipeline when the initial decision is made to subsequently either reverse or reaffirm the initial condition", using a new bound – a 'change-of-mind' bound (Resulaj et al., 2009). Although this model opens up the possibility for a change of mind process, it is still constructed from binary thresholds. In a recent study they propose a more continuous process. "Both decision making and sensorimotor control require real-time processing of noisy information streams. Historically these processes were thought to operate sequentially: cognitive processing leads to a decision, and the outcome is passed to the motor system to be converted into action. Recently, it has been suggested that the decision process may provide a continuous flow of information to the motor system, allowing it to prepare in a graded fashion for the probable outcome" (Selen et al., 2012). Their study attempts to show that during perceptual decision making, the accumulated sensory evidence for the decision is continuously represented in the human motor system (Kubanek and Kaplan, 2012).

Our results seem to be consistent with this model of continuous decision process and extend it to free-choice picking decisions (Furstenberg et al. 2012; 2013). We described a form of flow between the center (brain) and periphery (muscles), thus extending the meaning of the abovementioned 'continuous decision process' to mean continuous also temporally and spatially, between the center (brain) and periphery (muscles). As mentioned earlier, this continuous dynamical decision process is expressed in our experiment through the 'change of intention' structure which we observe not only over the motor cortex (via LRP) but in EMG activity in the non-responding arm which is followed by EMG activity and movement in the responding hand, parallel to the LRP 'change of intention' structure. We conclude that not only do *picking* and *choosing* situations express the same process defined by various *biases* interacting with one's *inner noisy state*, but that the very idea of a 'decision moment' in these situations is not at all a clear idea.

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[1] On the question of rationality in the context of picking selection cases see Weintraub 2012 (we owe a few of the traditional citations to this paper).

[2] Aristotle, *De caelo*, II 13, 295b24; trans. W.K.C. Guthrie, in the Loeb Classical Library series.

[3] *Summa theologica*,II, I, 13.6; cited from the translation of the Fathers of the English Dominican Province, 2nd edition, London, 1927.

[4] Spinoza, B. *Ethics*, in *Spinoza: Selections*. J. Wild, ed. New York: Charles Scribner's Sons, 1677: part 2, final Scholion.

[5] Note that in Leibniz's time the modern distinction between 'reasons' and 'causes' did not exist.

[6] Fourth letter to Clarke, §1, in *G. W. Leibniz and Samuel Clarke Correspondence*, Roger Ariew, ed. (Hackett Publishing company, Indianapolis / Cambridge, 2000). Citation according to note 52 there.

[7] Leibniz 1765, II, xx, 6; my emphasis.

[8] Quotes from Leibniz 1765, II, i, 15; my emphasis. For a more detailed account of these passages regarding the distinction between reasons and causes see Weintraub 2012, p. 285

[9] In contrast to the common usage in physics we are not describing a disordered system falling into one or another definite states as a result of very small fluctuations.

[10] For a conceptual justification for the usage of 'intention' in this context see Furstenberg 2013.

[11] This type of choice is termed by Mele 'liberty of indifference' (Mele 2009: 79-80).

[12] Frankfurt 1988.

[13] Ullmann-Margalit and Morgenbesser 1977, p.777.

[14] Ullmann-Margalit and Morgenbesser 1977.

[15] Sellars 1997.

[16] From a scientific perspective, science's role is to look for causes and map them out; therefore, from this perspective reasons *must* collapse into causes. The question remains: what is the exact connection and relationship between these realms - the '*space-of-reasons*' and the '*space-of-causes*'?

[17] See for example Ullmann-Margalit and Morgenbesser 1977; Mattler & Palmer 2012.

[18] Ullmann-Margalit and Morgenbesser 1977, p.763; compare to Leibniz 1765, II, i, 15..

[19] Ullmann-Margalit and Morgenbesser 1977, p.773.

[20] Ullmann-Margalit and Morgenbesser 1977, p.774.

[21] Mattler & Palmer 2012.

[22] Ullmann-Margalit and Morgenbesser 1977.

[23] Furstenberg et al. 2012.

[24] Going a step further, Furstenberg et al. (2012) propose to identify 'change of intention' when both opposing intentions (the initial and the overruling intention) were prompted endogenously.

[25] See Furstenberg et al. 2013.

[26] In their paper Bowman et al. call this layer the 'response layer'. However, since this name might be confusing when we talk about EMG and the responding hand, we modified the name to refer to neuronal activity within the motor cortex.

[27] See Furstenberg 2013.

[28] With EMG activity in the non-responding hand, matters get more complex – are we observing a low amplitude leakage from the pre decision-threshold stage or rather an inhibition of a motor decision? In this paper's context we do not expand on this matter.

[29] Mattler and Palmer (2012) proposed a similar relaxation of the decision criterion for the free-choice case.

FIGURES

Figure 1

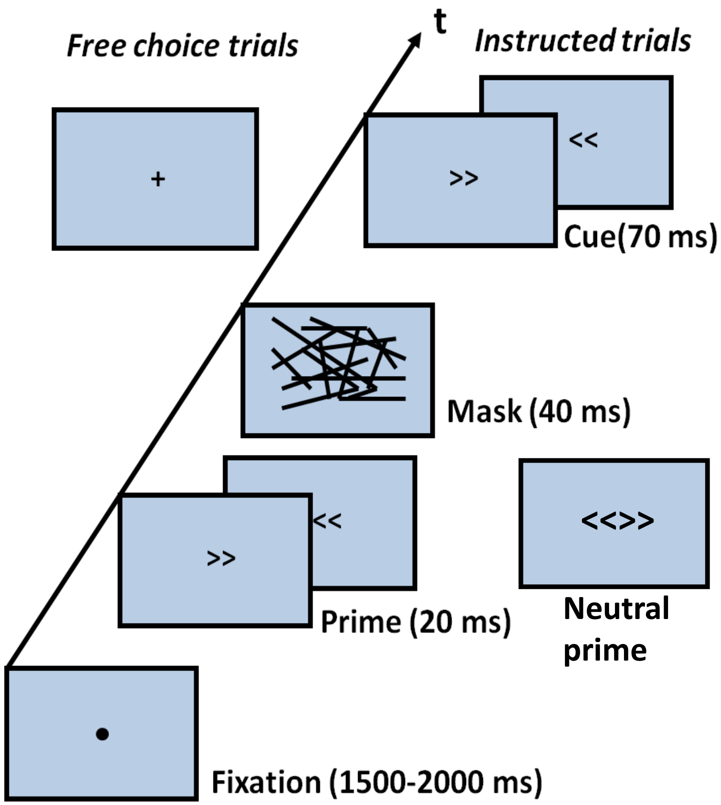

Figure 1 caption.
Experimental design. *Instructed* trials: following a fixation point at center of the screen a prime arrow directed either left or right appears. In a portion of the trials a two directional neutral prime appears instead of the arrow prime. This is followed by a mask screen composed of lines with random orientations and lengths. After the mask a visible arrow cue directed either left or right appears. *Free choice* trials: identical to *instructed* trials with a “free choice” cue instead of instructing cue. subjects were instructed to press rapidly with left or right hand according to what they want at the time of cue. Subjects were urged: no preplanning and to have roughly the same amount of left and right presses.
Congruent trials: cue (instructed trials)/response (free-choice trials) direction identical to prime direction. *Incongruent* trials: cue/response direction opposite to prime direction. *Neutral* trials: neutral prime.

Figure 2

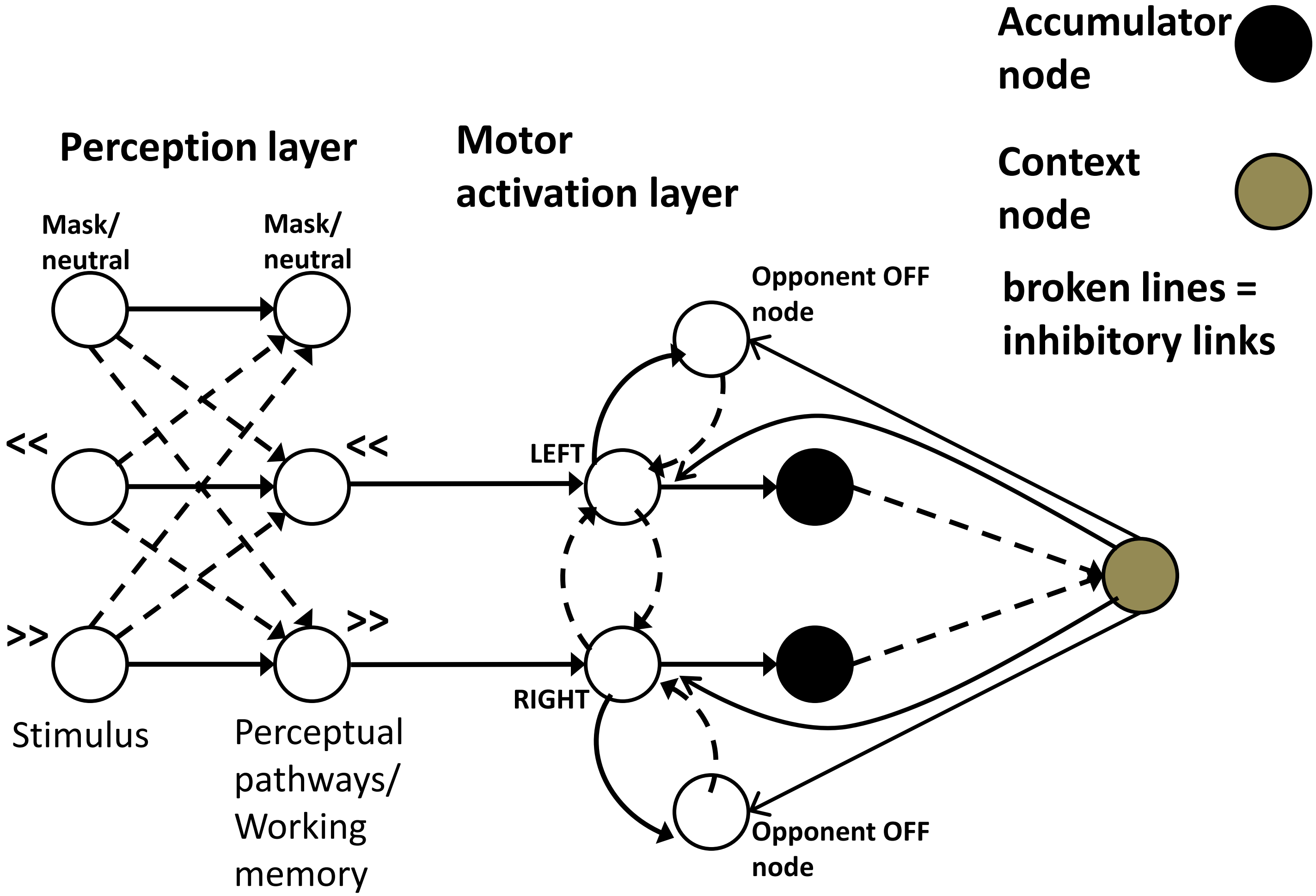
Accumulator node
Context node
broken lines = inhibitory links
Perception layer
Motor activation layer
Mask/ neutral
Mask/ neutral
<<
<<
>>
>>
LEFT
RIGHT
Opponent OFF node
Opponent OFF node
Stimulus
Perceptual pathways/ Working memory

***Figure 2 caption*.** The input into the motor activation layers is a result of a sustained, yet decaying, ‘perceptual trace’. The presentation of a backward masking stimulus cuts off the sustained perceptual trace, implemented as a neural competition mechanism using feedforward inhibition located between the stimulus layer and the perceptual pathway layer at which the decaying trace of the percept is sustained. Motor activation layer also implements a competitive mechanism, basically by lateral inhibition between the motor activation nodes (each node representing a different response: left and right). Moreover, each motor response activation node is connected to an opponent (OFF) node regulating the activation with an *excitatory* link to the OFF node and an *inhibitory* link from the OFF node. Selection criterion is based on accumulation in the accumulator nodes of the left and right motor activation nodes over time. The difference between left and right motor activation nodes is defined here as the LRP. Finally, the ‘context’ node provides excitatory input to the task-relevant motor activation nodes and OFF nodes, controlling the baseline activity of these channels with regard to the remaining channels; thus ‘switching on’ or ‘switching off’ the relevant channels.