Action, Imagery, & the N400

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Abstract

A framework is developed for the total human response to all potentially meaningful sensory stimulation within the window of *40* to *220ms* post-onset. The framework is intended explain the temporal invariance of the N400 ERP component (Kutas & Federmeier 2011), which is not a deadline for the 'binding' of a preliminary semantic *representation* (Federmeier & Laszlo 2009), but for anticipating needed system-wide change in preparation for *conscious control* in *action*. The pre-N400, *40* to *220ms* window includes Hebbian-like affective responses (Barrett & Bar 2009), recapitulation of sensory information, selection of LSF object and scene analogs (Fenske et al. 2006), guidance from scripts, and 'proxy percepts'. Proxy percepts are offered as an alternative to simulation. I illustrate the framework with a moment-by-moment scenario of a whale watcher smelling, hearing, and seeing 'a blow'. In conclusion, I argue that Noe's (2004) theory of virtual presence has use for proxy percepts and that proxy percepts offer an understanding of eye saccades more parsimonious than Grush's (2004) emulation account.

Keywords: N400; LSF; simulation; perception; language; action; emulation; conscious control; proxy percept.

Introduction

The human brain is perhaps most astounding in its ability to conjure reliably stable yet powerfully flexible meaning from an influx of impoverished, indeterminate, and noise-laden stimuli. Over the last thirty years, the study of the N400 ERP component has provided decisive insights into just this ability, measuring in real time the brain's response to all potentially meaningful stimuli (for most recent review, see Kutas & Federmeier 2011).

A recent advance in N400 theory takes account of the temporal invariance of the N400. Federmeier and Laszlo (2009) hypothesize that the N400 indexes a deadline for the 'binding' of a preliminary semantic *representation*. The current framework resists this hypothesis and begins with a somewhat different functional characterization: the N400 rather indexes a deadlined anticipation of needed system-wide change for *conscious control* in *action*. To explain this, the framework focuses on the total human response to all potentially meaningful sensory stimulation within the window prior to N400: *40* to *220ms* post-onset. This window is exceptionally dynamic and includes Hebbian-like somatic and affective responses (Barrett & Bar 2009), recapitulation of low-level sensory information, selection of LSF object and scene analogs (Fenske et al. 2006), guidance from existing scripts, and most critically, what I call 'proxy percepts'. Proxy percepts are a refinement of, or perhaps an alternative to, 'simulation' during perception, thought, and language comprehension.

In what follows, I briefly introduce N400 research and then develop key features of the proposed framework. This is followed by a development of the details related to the *40* to *220ms* time window. I bring these details together in a moment-by-moment millisecond drama of a whale watcher smelling, hearing, and seeing 'a blow'. I elaborate this scenario in the argument that Noe's (2004) theory of 'virtual presence' is in need of proxy percepts, and I conclude by differentiating my framework from Grush's (2004, 2007) emulation account of sensory expectation. I argue that proxy percepts offer an understanding of eye saccades more parsimonious than Grush's (2004) emulation account.

N400

Some years after the discovery of stimulus modulated voltage potentials at the surface of the scalp, a number of reliable ERP 'components' where demonstrated, and by the early 1980s, Marta Kutas had discovered an ERP component in the *200* to *600ms* window reliably modulated by the expectancy of linguistic stimuli. This component was titled 'N400' since it peaked negatively, close to *400ms* post-stimulus onset. However, grammatical violations, and even physical manipulations, such as 'I shaved off my mustache and beard/BEARD', had no effect. The N400 was therefore associated with the *semantic* processing of linguistic stimuli.

Curiously, though, not all sentential framing of semantic stimuli produced N400 effects, as in the case of negation; whereas, semantic category and lexical priming did modulate the component. More critically, researchers were not long in discovering similar N400 effects elicited by *non-linguistic* stimuli, such as objects, line drawings, and pictures. Yet, some structured domains, such as music, had no effect. The picture that emerged, and a picture that has received only growing confirmation over the last two decades, was an ERP N400 component that reliably indexed the brain's universal response to all *potentially meaningful* stimuli (Kutas and Federmeier 2011).

Critically, the N400 is a continuous and instantaneous electrophysiological measure of neocortical activity. Given the low temporal resolution and indirect nature of behavioral measures and imaging techniques such as fMRI, the N400 is a relatively powerful tool that has offered unexpected guidance to long standing debates. For example, N400 data have provided powerful evidence against all strict modular theories of language comprehension.

A somewhat course-grained account of N400 effects has proven sufficient to motivate continued inquiry into the N400's functional characteristics. The 'normal' amplitude of the N400 for a target word presented in isolation is reliably reduced by a facilitating context. This facilitation is universally explained as an index of the decrease in difficulty, or inversely, the ease, of language processing. Theorists have offered finer-grained accounts based on this common assumption. On one view, decrease in N400 amplitude indexes the ease of semantic access, facilitated by efficiencies of Long Term Memory structure (Federmeier and Kutas 1999). On another view, decrease in amplitude indexes the greater ease of post-lexical integration (Hagoort et al. 2009). A third approach seeks to harmonize these two accounts (Lau et al. 2008).

General Framework

The present framework begins with the N400's remarkable trait of temporal invariance. Investigating what controls the N400's stable timing is one of the eight directions for future research recommended by Kutas and Federmeier (2011) and, as already noted, only recently Federmeier and Laszlo (2009) functionally characterized this invariance as the deadline for 'binding' an "initial semantic representation."

However, theorists attempting to ground meaning in experience are likely to be wary of an appeal to 'representation' just here, at least to the extent that meaning *just is* specific activation of sensori-motor mechanisms underlying perception and action (Zwaan 2009; Zwaan and Kaschak 2008; Dils & Boroditsky 2010; Barsalou 2009; Bergen et al. 2010; Gallese 2009). More critically, the meaning *of* a stimulus must be activation operationally indexed to that stimulus; but as soon as reference is made to a *representation* or a final-state meaning, grip on this stimulus index is loosened. From the standpoint of ERP experimental procedures, traditional reference to semantic representation may be vacuous.

The present framework approaches meaning in terms the configuration of neural activity that is bound together in response to some stimulus T, at some time *t*; but without recourse to cognitive *representations*, it is important to add the following: the meaning of T is defined in terms of the *onset* of T, at t_0. The *emerging* meaning of T can be characterized only in terms of a *change* in the configuration of neural activity between the time of an arbitrary probe at t_1 and stimulus onset, t_0 ($t_1 - t_0$).

But what then do we do with the primitive notion of *the meaning* of T? Critical to the present framework is the hypothesis that N400 is an index of the result of early predictive processes from t_0 to *220ms* post-onset. What is predicted is the change in system-wide activity amounting to meaning, which just is the change needed for *conscious control* in *action*, as indexed to onset of T (Unconscious control deriving meaning only analogically from the domain of conscious control). The 'semantic system' in view will include any organism specific change that the organism finds salient to *action* with respect to the onset of T. This might include bodily changes from the hairs of the head to the tips of the toe nails—and it might not. I am bound to argue, albeit outside the scope of this short paper, that this framework accounts for all extant N400 data; it was originally developed for no other purpose.

T would not be a cognitive input if presented in pure isolation, translating to noise if registered as anything beyond the sensory interface or else is ignored altogether. But pure isolation is not empirically probable and may even be physically impossible. The real onset of interest is T and a relevant context (C). The onset of T instantiates an immediate, dynamic, bidirectional interaction between C and T, or, C↔T. The system has a *~220ms* deadline to assign a stable and limited set of 'salience' parameters based on C↔T. The notation for these assignments is F{P,U,N}, where F is a three dimensional return that operates as the vehicle of prediction. P labels the extent to which C↔T was predicted; U, something like the unexpectedness or valence of C↔T; and N, the level of suppression of P and U. Presumably, the return of F values is a LH dominant process (Federmeier 2007), determined as they are by a limited set of system expectations. The interaction between all three assignments (P,U,N) and C provide a rich informational source for determining, by the *~220ms* deadline, the Resultant Force (R*f*), which is the *predicted* enacted change in system-wide activity necessary for the optimal response to C↔T, as indexed to onset of T. So far then: $[\ (C \leftrightarrow T) \rightarrow F\{P,U,N\}\ ] \rightarrow Rf$. The return of F is only a partial solution to the paradox of a system processing T before T is registered as unexpected or not (Bar 2007).

The N400 peak at *~375ms* represents either the binding of information for the future launch of system-wide change, or else a binding of the resulting system-wide change itself. Given the relatively long time window from *220ms* to *500ms*, as well as the possibly related phenomena of attentional blink from *200ms* to *500ms*, I will tentatively assume that the *375ms* peak indexes the greatest concentration of changes in resultant system-wide activation as the system prepares itself directly for conscious control in action. Settling this question empirically should be relatively straight-forward as researchers combine N400 topography (Barber et al. 2010) with MEG (Lau et al. 2008), MEPs (Jeannerod 2001), and task interference data (Bergen et al. 2010).

Some Framework Details

The present framework can be elaborated in terms of a refinement of, or alternative to, 'simulation' theory. The following is a brief outline of the literature on simulation: Simulation predictively facilitates low-level perception, or else runs a high-level modular process returning discrete outputs for propositional attributions (Goldman 2006). Simulation can be either skeletal or vivid (Barsalou 2009). Simulation is by definition consciously accessible (Moulton & Kosslyn 2009) or prototypically covert (Gallese 2009). Simulation can be a dynamic-like re-enactment of experience (Zwaan & Kaschak 2008), producing the experience of 'being there' (Barsalou 2009), but is typically only a partial ordering of event structure (Barsalou 2009), mimicking the sequence structure of a situation for epistemic purposes (Moulton & Kosslyn 2009). Generally, the extent to which any form of imagery or simulation is static, versus dynamic, is left ambiguous.

Some simulation theorists acknowledge the imprecision in many of these accounts, calling for better specifications of how simulation relates to meaning—linguistic meaning in particular (Zwaan 2009, Barsalou 2009). Enter 'proxy percepts'.

Proxy Percepts The 'proxy percept' hypothesis is rooted in the idea that imagery is constituted by sensorimotor mechanisms underlying perception and action only because imagery was originally developed *for* perception and action. In higher-level cognition, such as daydreaming, language comprehension, and counterfactual planning, an image operates as a 'stand in' or *proxy* object of actual experience in the absence of direct sensory stimulation, but only because this is the precise role the image already played in actual situations of perception and action.

In the case of language comprehension, there are two moves: 1) A word can be meaningful in virtue of its elicitation of an image. The image in turn can operate as a proxy percept, eliciting the kind of system-wide changes in preparation for action as if that percept was environmentally elicited. 2) Language can effortlessly and effectively elicit proxy percepts only because the system had already learned how to do just this irrespective of language, while hunting, gathering, socializing, fighting, building, and fleeing. Our perceptual-motor system always relies on such proxy percepts: the tiger that hid behind the tree, the middle section of the snake now occluded by the rock, the 'actual' size of the person seen at a distance, the anticipation of what the tree section will look like once my current downward stroke of the ax is finalized, or the mere *stable unity* of a moving object fluttering about through the bushes and trees, not yet perceived unoccluded long enough to qualify as a poisonous insect or leaf blowing in the wind.

Any predictive pre-sensitization can qualify as a proxy percept. For example, at the millisecond scale, with clear analog to human psychophysiology, the monkey's retinal receptive fields are remapped in anticipation of a coming eye saccade (Grush 2004), based on extant parafoveal information and a copy of an eye saccade command.

Imagery Motor and visual imagery can be pulled apart (Flusberg & Boroditsky 2010), but the format of both visual and motor imagery may mirror the static format of perception. In addition to traditional examples of motion illusion and 'representational moment', it is notable that static images implying motion produce similar MAEs as imagined motion (Dils and Boroditsky 2010). Further, perception of motion often requires additional information from the vestibular system (Palmer 1999) and activity in MT+, a known correlate to motion processing, was recently shown to respond to both literal and fictive motion language (Saygin et al 2010), even though fictive motion references 'images' that *do not move*. It is therefore possible that the sensori-motor system perceives, remembers, and behaviorally enacts motion in static formats, conjoined only ecologically (Noe 2004) with actual motion in the environment. This hypothesis is independently motivated by considerations of processing efficiency and so should at least mitigate the natural inclination to impute dynamic features to sensorimotor simulation or emulation. If a static visual image has the "drawing sense of whither it is to lead" (James 1890/1950), how much more so for motor imagery when the system is poised for action.

Recognition The ability of a proxy percept to facilitate the return of F does not entail the system's capacity to judge *that* T is caused by 'an O' or to recognize T *as* 'an O'. This is consistent with ERP data that decouples N400 effects from recognition (Kutas & Federmeier 2011).

Affect System change elicited before the *220ms* deadline has indirect semantic effects. Non-semantic, direct Hebbian-like links may elicit preliminary change based on C↔T—in some cases just T—generating important updates to C, in turn facilitating the response to T. This process seems well captured by Barrett and Bar's (2009) work on affect, in which immediate affective responses facilitate object recognition. These pre-semantic responses differ from later activation set in motion by R*f* in that they do not directly induce the binding of sensori-motor poise supportive of conscious control. This distinction is evidenced by a preliminary feed-forward sweep of stimulus information to the orbitofrontal cortex (OFC) *80* to *130ms* post-onset (well within the deadline of R*f* prediction), followed by a second wave of OFC activity between *200* and *450ms* (Barrett & Bar 2009) remarkably similar to the window after R*f*, spanning N400 onset to N400 peak. According to Barrett and Bar, face perception ERP results produced a similar finding.

RH Recapitulation Low-level information of T may be retained for later use. According to Federmeier (2007), this is responsible for lateralization of N400 effects. Consistent with earlier P2 component effects, LH appears sensitive to the semantic similarity between T and low-level predictions for T, whereas RH appears sensitive only to the semantic similarity between contextual information and T. Federmeier therefore views LH as predictive, with greater reliance on 'top-down' processes, increasing efficiency and decreasing noise. Alternatively, RH is integrative, with greater reliance on 'bottom-up' processes, giving the system flexibility to use stimuli that is plausible but less predictable. However, according to the present framework, predictions for T contribute to C generally, and the semantic 'fit' between less-predicted features of C and C↔T plays a predictive role. On the present framework, this simplifies to parallel processes leading to the production of R*f*.

The N400-indexed processes that follow, however, are relatively encapsulated. The system may even need to 'blink' from roughly *200ms* to *500ms* post-onset to 'run with' R*f* and induce necessary system-wide change. Before the R*f* deadline however, predictive mechanisms responsible for producing R*f* might make continual use of RH *recapitulated* low-level information obtained at onset of T.

Associations vs. Scripts Bar's theory of object recognition (2009; Fenske et al. 2006) is based on low spatial frequency visual input (LSF) given preliminary sweep to OFC. This information functions as an a LSF 'object', capable of generating multiple analog candidates drawn from memory. However, LSF is also speedily propagated through a parallel 'where' stream, creating a scene analog that provides predictions for the object's global surrounding. The dynamic integration of these two processes facilitates selection of the appropriate object analog and situates the object within a global scene as HSF information quite literally fills in the details of what the object is predicted 'to be'.

Critically, context does not penetrate the initial LSF process of selecting object analogs, as evidenced by one study demonstrating equal priming effects for multiple objects as early as *130ms* post-onset. But a similar process is not proposed for initial scene selection. How, then, is the appropriate scene analog generated which then helps select the right object analog? According to Bar's account of associations, even objects in isolation have the capacity to generate 'context frames', calling up possible scenarios and other kinds of objects. 'Clusters of associations' must be linked together through specific scenarios, such as a dinner plan scenario when planning for dinner (Bar et al. 2007). Elsewhere, Bar refers to such linking as the function of *scripts*. Simulations for complex situations (2009) form scripts. Guidance in thought and action are provided by approximated, rudimentary scripts (Bar 2007).

Yet, how scripts relate to association is left ambiguous. Examples given of 'context frames' are limited to objects spatially arranged in static scenes. The present framework understands scripts as providing a unique type of event structure. Scripts are abstract and temporal, capable of ordering most real-world scenarios and thereby supplying an independent source of predictions and subjective expectation. Scripts can therefore facilitate or determine the fast selection of LSF scenes that then guide the selection of one of the activated analog objects. Since true isolated onset of T is impossible, some sort of script structure should be active as part of C. C↔T therefore comes with inherent temporal event structure. R*f* may primarily target the change of a global script while leaving in tact most pre-existing sensorimotor activation, as in the case of a 'frame-shift' (Coulson 2001) elicited by the punch-line of a joke.

The Whale Watch

All these pre-N400 elements are brought together in the following example. Please imagine yourself standing mast-head on a whale ship, 'a hundred feet above the silent decks, striding along the deep'. You are a professional watchman, well-trained and disciplined. Your eyes, loyal to the purposes of your captain, are awake in their sockets, roaming the now mildly turbid, fog-laden ocean.

At *t = -400ms* (note the negative sign), the odor particular to a sperm whale (T_1) is registered and triggers the beginning of an affective response at *t = -300ms*. The system has not yet recognized a sperm whale odor, but Hebbian-like links elicit greater activation in sensori-motor poise, pre-sensitizing the auditory and visual system to hear and see 'a blow'. This-way-and-that, the body, head, eyes, the balance on the ropes, poise themselves for where the source of an actual odor may be. Because of this odor-elicited increase in perceptual poise, a parafoveal visual input at *t = -200ms* (T_2) reaches threshold for an eye-saccade command at *t = -150ms*. A copy of this command pre-sensitizes the retinal visual field in preparation for the foveal input once the saccade and coordinated head and body movements are complete. We will call all this C_1.

At *t = -100ms*, we make our first probe, generating the baseline for whatever N400 component we might find. Then, at *t = -50ms*, an auditory signal is registered (T_3), a prototypical slap against the water, generating C_2. However, our probe was placed in view of visual stimuli, and so N400 will be indexed to the onset of T_4 at t_0 (*t = 0ms)* when the fovea now takes in preliminary information from the environmental location that originally elicited the saccade. Our first artificial stimulus *onset* is defined as $C_2 \leftrightarrow T_4$ (See Figure 1). By *t = 80ms*, T_4 has triggered a direct affective response, eliciting activation in RH that recapitulates T_3 at *t = 110ms*, now referenced as T_R. The conjoining of T_4 and T_R in $C_3 \leftrightarrow T_4/T_R$ elicits a preliminary, highly covert proxy percept at *t = 160ms*. This proxy percept—a rudimentary image rather than identification, classification, or recognition—is that of 'a blow'.

However, the preliminary LSF sweep of information garnished from T_4 to OFC, already having occurred at *t = 120ms*, has primed two analog objects: 1) a typical sperm whale, and 2) Moby Dick. The already extant global event structure, the *script*, selects a chaotic scene with a vengeful whale (the watchman had a nightmare about Moby Dick the night before). Thus, the script had determined the LSF scene, which in turn had selected, at *150ms*, the Moby Dick analog LSF object. Accordingly, the proxy percept elicited at *t = 160ms* was not just a covert image of a typical sperm whale, but of the White terror, Moby Dick. The HSF information begins filling in the details of the proxy percept of Moby Dick, to result inevitably in 'vivid' imagery, but the initial covert proxy percept was the cause of the final F values returned by *220ms*. The time window of an attentional blink began at *t = 210ms* and at *230ms* R*f* was launched.

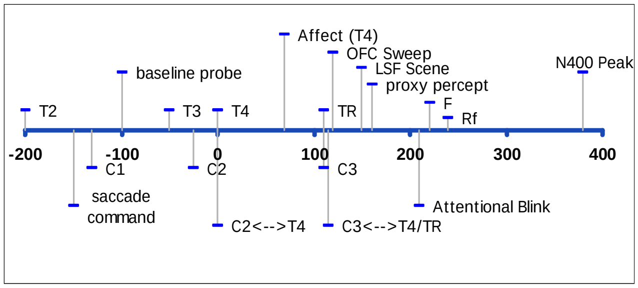

Figure1

The system-wide change indexed to onset of T_4 peaked at *380ms*. The phenomenal aspect of what would have been Moby Dick imagery was in fact a successful Moby Dick perception. The proxy percept *became* an actual percept as the predicted HSF information arrived. Consciousness has so far been epiphenomenal, but by *t = 480ms*, the system is now semantically poised for conscious control. The cry of 'There she blows!' is just below behavioral threshold by *t = 550ms*, conjoined with heightened "sympathetic outflow" in "preparation for action" (Jeannerod 2001). But the watchman has a 'decision' to make and by *t = 700ms* the cry is suppressed. The *meaning* of T_4 after all—the binding of increase in heart and respiration rate, and the ‘feel’ of the motor poise predicted optimal for the original covert proxy percept of that merciless beast—is something the watchman deems wise to keep to himself, lest he and his captain die that very day.

The only invariant features of this hypothetical scenario are the onset of the stimulus of interest (T_4), R*f*, N400, the preliminary OFC sweep, the return of F values somewhere between *50* and *220m*s and, presumably, the attentional blink. Critical is the dynamic use of all input, including recapitulated input, for the development of C_n in $C_n \leftrightarrow T_4$ that results in the R*f* prediction indexed to T_4.

As for language: we can view linguistic stimuli as environmental stimuli. What else could it be? The field of N400 research has roundly refuted a semantic distinction between objects and language, in any case. Proxy percepts are efficiently multiplied during language comprehension, just as they might be on a chaotic foggy evening while hunting the White Whale. I provisionally understand grammatical structure as the result of 'equilibrium', in which N400 amplitudes are statistically diminished with increased processing of perceptual linguistic information. This equilibrium may be well captured by Callahan et al.'s (2008) report that null anaphors decreased overall reading time, yet increased N400 amplitude for the following word.

Noe, Grush, & Sensory Expectation

I will conclude by focusing on where Noe (2004) and Grush (2004, 2007) tell somewhat different stories; this is designed help define the unique role that proxy percepts played in the whale watching illustration above. This will in turn move the general framework to a more empirically motivated account of ‘simulation’—or a substitution for it.

Noe On Noe's view, the awareness of anything outside the effects of sensory stimulation is 'virtual presence'; this includes everything: from the thoughts of places thousands of miles away to the volumetric 'feel' of the occluded backside of a perceived tomato. Virtual presence just is our 'skill' in anticipating, a 'taking ourselves to have access to', the sensory stimulation that would be conjoined with our bodily movements if these movements were to bring us into direct sensory contact with the occluded surface; this presumption of access constitutes a virtual kind of phenomenology. But proxy percepts are not fully 'virtual' in this way and therefore have no place in Noe's account. But I think Noe could make use of these 'light-weight' representations, at least to help mitigate the dilemma lurking in the distinction between the phenomenology of sensory stimulation and the phenomenology of virtual presence. The mechanisms underlying each are, it seems, mutually exclusive. *Having access indeed* to sensory stimulation is a distinct kind of process different in kind to *'taking oneself* to have access' to sensory stimulation.

I offer my framework as more parsimonious, in which there is no definitive distinction between the development of a covert proxy percept of O and the arrival of an actual perception of O. The whale watcher's system did not 'know' at $t = 160ms$ that the covert proxy percept formed by the conjoining of T_4 and T_R in $C_3 \leftrightarrow T_4/T_R$ would in fact *become* the preliminary presensitization or prediction of an actual non-occluded percept. Until the sensory stimulation arrives, if it does arrive, 'top-down' mechanisms are available as if a whale was directly seen. Consider for example the increased activity in MT+—a known correlate to motion processing—when a subject either sees a whale in motion, or observes static images of a whale implying motion, or imagines a whale in motion (Saygin et al. 2010), or simply hears a long story about a moving whale (Dils & Boroditsky 2010).

Proxy percepts also explain our 'closeness' to distal objects. The farther away the object, the less my own movements make any difference to retinal stimulation, saccades, and parallax information (Palmer 1999). We loose grasp of distant objects in terms of Noe's sensorimotor contingences, and yet the human imagination is still able to bring those objects 'to hand.' Through imagery, the distal tree branch can enjoy a movement-dependent relation only as I blend (Coulson 2001; Fauconnier & Turner 2002) my current perception of the non-occluded tree branch with its proxy version in a motor domain (e.g. what it would be like to climb up the tree).

Grush I wrap things up with Grush's emulation theory. The theory states that sensory information is processed 'into' perceptual information through a continuous, corrective interaction between 1) the estimates produced by internal emulators that emulate some external process, and 2) observations of that process (2007):

$$p''(t) = p'(t) + k\,r(t) \qquad (1)$$
$$p'(t) = V\,p''(t-1) + c(t) \qquad (2)$$

In (1), $p''(t)$ is the a posteriori estimate of the current state of the external process $p(t)$, arrived at by the combination of the emulator's a priori estimate, $p'(t)$, and the process that happened as observed, $r(t)$. k represents how the system interprets the *sensory residual* (2004), which is derived from the difference between the a priori signal estimate generated from $p'(t)$ and the actual observed signal $r(t)$. The sensory residual could be a result of unaccounted external influences on $p(t)$, as when the system has poor knowledge of how the process of $p(t)$ evolves through time, or it could be the result of sensor noise, as when the sensor is functioning poorly. In (2), the derivation of $p'(t)$ is shown, a function of the known influence of the brain on the external process, $c(t)$, and the prior a posteriori estimate, $p''(t-1)$, evolved dynamically according to the system's knowledge of how $p(t)$ should go, represented by V.

My framework forces a nuanced approach to observations, $r(t)$, and a priori estimates, $p'(t)$. On Grush's emulation model, $r(t)$ represents, as far as I can so far tell, a modular process, perhaps similar in autonomy and context impenetrability as the LSF priming of multiple analog objects (see above). k is formulated through a separate process of filtering, and $r(t)$ is then 'combined with' the a priori estimate, $p'(t)$. $r(t)$ therefore looks a lot like my framework's T. But T is found within a $C_n \leftrightarrow T$ dynamic, and according to the F values produced from this dynamic and the resulting R*f* by the *~220ms* deadline, N400 amplitude linearly decreases *to zero* as context is 'built up'. This implies a general information heuristic in which system expectations highly predictive of precisely T do not merely reduce a sensory residual; they allow T to *disappear* altogether. I suggest that this is the perceptual norm. Further, because of the parallel, bi-directional dynamic, the filtering of noise is inherent within $C_n \leftrightarrow T$.

This heuristic floats up to the higher-level role of proxy percepts. Again, the remapping of the retinal receptive fields based on an early copy of an eye saccade command can be considered a low-level proxy percept, which is similarly presented by Grush (2004, 2007) as a case of modal emulation. But rather than viewing this presensitization as an independent a priori estimate (and the resulting foveal input a modular process of observation), I take it as the *becoming* of a successful event of perception, just as a selected LSF object analog is the *becoming* of the parallel arrival of HSF perceptual information.

The process of emulation observation and measurement could, perhaps, be characterized in terms of a $C_n \leftrightarrow T$-like dynamic: $[\, p'(t) \leftrightarrow r(t) \rightarrow k \,] \rightarrow Rf \rightarrow p''(t)$ patterned after $[\, C_n \leftrightarrow T \rightarrow F\{P,U,N\} \,] \rightarrow Rf \rightarrow C_{n+1}$. But then $p'(t)$ no longer stands alone as a model of $p(t)$, but is rather whatever preliminary presensitization is required to determine the salience of $r(t)$, which *just is* $p'(t) \leftrightarrow r(t)$. $p'(t)$ would then be an intrinsic part of the saccade event. Ultimately, this is an empirical question, and I am designing a template for ERP experiments that may help confirm or disconfirm the framework motivating the theory of proxy percepts.

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