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Assuming too much from 'familiar' brain potentials

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Familiarity is sometimes associated with midfrontal old/new (FN400) signals, but investigators assume too much by inferring familiarity whenever they identify these signals. We describe how Rosburg and colleagues (2011) made this assumption, yielding potentially faulty conclusions about the recognition heuristic. We provide an alternative interpretation emphasizing implicit processing that can underlie decision-making.

In their article 'When the brain decides: a familiarity-based approach to the recognition heuristic as evidenced by event-related brain potentials', Rosburg and colleagues [1] attempted to identify the source of a noteworthy decision heuristic. Apparently, this recognition heuristic was used by individuals trying to decide which of two cities was larger; they tended to choose the most recognizable city name instead of actually evaluating the relative populations. The authors concluded that familiarity is at the heart of this heuristic. However, we believe that the reasoning underlying this conclusion is faulty. Here, we present arguments in favor of an alternative interpretation that went unmentioned in their article, namely, that implicit memory provides the basis for the heuristic used in such judgments.

Electroencephalography (EEG) results were interpreted as showing that the experience of familiarity determined participants' size decisions. This reverse inference, however, is incongruous with the considerable controversy about the link between familiarity and the specific brain potential identified in this experiment, the midfrontal old/new effect (or FN400). Our view is that FN400 signals do not generally correlate with familiarity; they only do so in restricted circumstances, when conceptual implicit memory closely co-varies with familiarity. This interpretation would suggest a fundamentally different account of the recognition heuristic. The interesting data published by Rosburg and colleagues must be re-evaluated in light of these ideas.

During a recognition test, familiarity is an expression of 'explicit memory', which is demonstrated when participants endorse an item as having been presented earlier. Familiarity is a subjective experience of memory retrieval that occurs without the recall of relevant contextual details, such as when or where the item was encountered before. 'Implicit memory', on the other hand, refers to a set of memory expressions wherein participants need not realize that their behavior has been influenced by past experience. For instance, participants can respond faster or more accurately when items are repeated in priming tests, despite evincing no explicit memory for the prior encounters. Of particular relevance here is 'conceptual implicit memory', which involves facilitated implicit processing of conceptual stimulus attributes owing to prior experience. Familiarity and conceptual implicit memory co-occur in some situations, but not others. Moreover, the processing underlying conceptual implicit memory may contribute to familiarity for some items and not others, and this processing can transpire even when conceptual implicit memory is not measured by the experimenter. Careful steps must be taken to disentangle these memory phenomena and their respective neural correlates, as we have previously recommended [2].

A summary of evidence that FN400 potentials are not dependable indicators of familiarity is shown in Figure 1, along with one specific example. In memory experiments, familiarity judgments for words and nameable pictures are associated with FN400 effects [2,3], but familiarity judgments for less meaningful stimuli, such as complex geometric patterns and Gabor patches, are not [4–6]. Importantly, certain stimuli convey conceptual meaning to some individuals, but not others. In these instances, FN400 effects are absent for stimuli that are perceived as low in meaning, while still evoking strong experiences of familiarity (e.g., [7]). Additional evidence (reviewed fully in [8], along with a thorough development of this reasoning) also links FN400 signals to implicit conceptual fluency, including findings that: (i) FN400 effects preferentially correlate with behavioral measures of conceptual priming, not familiarity, when the two are disentangled; (ii) FN400 correlates of conceptual priming can be distinguished from neural correlates of explicit memory, thus reinforcing the decoupling of FN400 effects from explicit memory; and (iii) FN400 potentials bear a close relationship with N400 potentials, which are associated with conceptual processing in a wide range of contexts.

Whereas the conclusions of Rosburg *et al.* assume an exclusive relationship between FN400 effects and familiarity, this one-to-one mapping is untenable. Their conclusions stem from a widely held but misguided view that inappropriately emphasizes familiarity, such that the potential for implicit memory mechanisms to influence the recognition heuristic was ignored. Their familiarity-based account of the recognition heuristic is appealingly straightforward: one infers that the city experienced as more familiar is the larger city. Our emphasis is on implicit memory instead, opening the door to other possibilities. Indeed, there is a growing literature on the role of conceptual and other types of fluency in heuristic-based decisions, including judgments of recognition, truth, and liking (e.g., [9]). According to some

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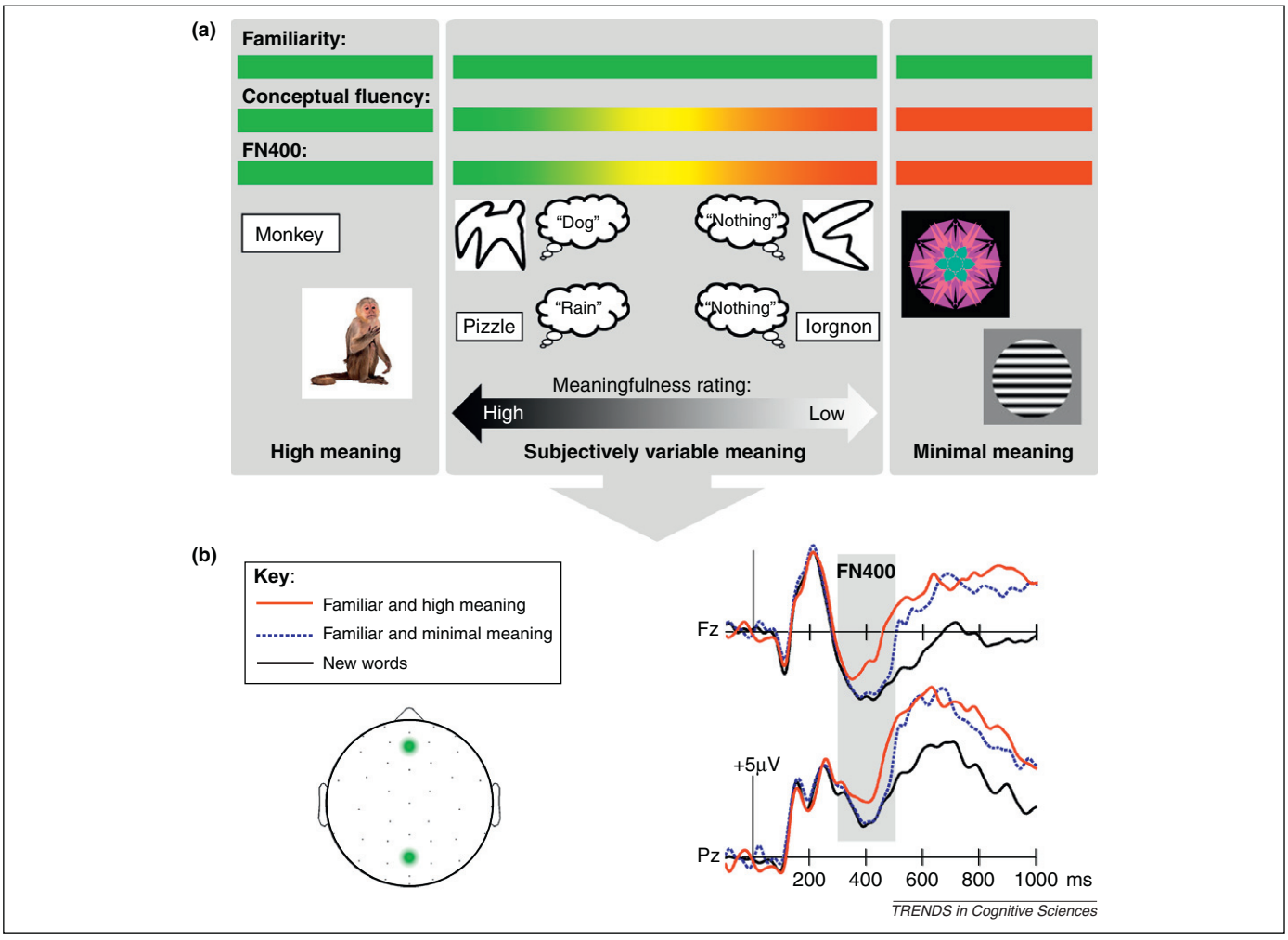

Figure 1. Summary of evidence linking FN400 brain potentials to conceptual implicit memory rather than to familiarity. **(a)** Stimulus meaningfulness can be used to disentangle familiarity and conceptual fluency, and their neural correlates. The magnitudes of familiarity, conceptual fluency, and FN400 are shown along a continuum of strong (green) to weak (red), according to variations in stimulus meaningfulness. In repetition paradigms, stimuli that are inherently high in meaning (left) produce familiarity, conceptual fluency and FN400 effects [2,3], whereas stimuli that are minimally meaningful (right) produce familiarity, but not conceptual fluency or FN400 signals (e.g., 4-6]. Stimuli that vary idiosyncratically across individuals in meaningfulness (middle) support familiarity irrespective of rated meaningfulness, but produce conceptual fluency and FN400 signals only when rated as relatively meaningful (e.g., [7]; see [8] for a review). FN400 potentials therefore track conceptual fluency rather than familiarity. The erroneous inference of a generic link between familiarity and FN400 signals has arisen because familiarity and conceptual fluency co-occur in some conditions. **(b)** FN400 brain potentials are shown for visual words that were matched for familiarity but varied in the degree to which they were thought by the viewer to be meaningful [7]. Electrode locations are indicated by green circles on a schematic view of a head. In implicit memory tests, conceptual priming was preferentially observed for words that were relatively high in meaning. Words rated as relatively low in meaning were essentially treated as pronounceable letter strings; they evoked little meaning and did not support conceptual priming, but some could still be recognized. FN400 effects (relative to a new-word baseline) were observed in conjunction with familiarity-based recognition only for the high-meaning words, and FN400 signals were thus associated with conceptual fluency instead of familiarity. In contrast, familiarity was consistently associated with brain potentials occurring after FN400 effects (beginning about 500 ms after word onset), given that amplitudes were greater than baseline when familiarity-based recognition was indicated for words from either meaningfulness category. Adapted, with permission, from [8].

accounts, familiarity itself can arise from the unconscious attribution of fluency to prior experience [10]. However, conceptual fluency can occur without concomitant familiarity, and familiarity can be triggered by types of processing other than conceptual fluency. It is thus important not to conflate these memory phenomena or their neural correlates so that we can ultimately achieve a better understanding of how they relate to one another.

This methodological critique, moreover, is of general relevance; the limitations of reverse inference should be considered whenever investigators attempt to use neuroimaging to better understand psychological processes. In this case, FN400 potentials might have been reliable signals of familiarity if conceptual fluency was tightly coupled with familiarity across all the trials in the experiment, but it would nonetheless be presumptuous to conclude that familiarity was operative in this way without additional evidence. FN400 signals indicate only one possible familiarity source, not familiarity itself. Even if *a priori* hypotheses support the approach of inferring familiarity based on FN400 data (and of disregarding alternative hypotheses), such an approach is contrary to the goal of using EEG to gain novel insight into the relevant neurocognitive mechanisms. The same reasoning applies to many other attempts to infer familiarity (and other cognitive phenomena) based on neuroimaging data [8].

The EEG analysis methods utilized by Rosburg and colleagues can be an informative means to examine brain signals relevant to human decision-making. However, inferences of subjective states such as familiarity from

neural signals must be made with care, and in this case the possibility that implicit processing was operative failed to come to light. This oversight precluded an essential category of neurocognitive mechanism that allows decisions to be influenced by information not consciously accessible to decision makers.

References

1 Rosberg, T. *et al.* (2011) When the brain decides: a familiarity-based approach to the recognition heuristic as evidenced by event-related brain potentials. *Psychol. Sci.* 22, 1527–1534
2 Paller, K.A. *et al.* (2007) Validating neural correlates of familiarity. *Trends Cogn. Sci.* 11, 243–250
3 Rugg, M.D. and Curran, T. (2007) Event-related potentials and recognition memory. *Trends Cogn. Sci.* 11, 251–257
4 Danker, J.F. *et al.* (2008) Characterizing the ERP old-new effect in a short-term memory task. *Psychophysiology* 45, 784–793
5 Voss, J.L. and Paller, K.A. (2009) Remembering and knowing: electrophysiological distinctions at encoding but not retrieval. *Neuroimage* 46, 280–289
6 Yovel, G. and Paller, K.A. (2004) The neural basis of the butcher-on-the-bus phenomenon: when a face seems familiar but is not remembered. *Neuroimage* 21, 789–800
7 Voss, J.L. *et al.* (2010) Conceptual priming and familiarity: two different expressions of memory during recognition testing with distinct neurophysiological correlates. *J. Cogn. Neurosci.* 22, 2638–2651
8 Voss, J.L. *et al.* (2012) More than a feeling: pervasive influences of memory without awareness of retrieval. *Cogn. Neurosci.* http://dx.doi.org/10.1080/17588928.2012.674935
9 Alter, A.L. and Oppenheimer, D.M. (2009) Uniting the tribes of fluency to form a metacognitive nation. *Pers. Soc. Psychol. Rev.* 13, 219–235
10 Jacoby, L.L. and Dallas, M. (1981) On the relationship between autobiographical memory and perceptual learning. *J. Exp. Psychol. Gen.* 110, 306–340

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Response to Paller *et al.*: the role of familiarity in making inferences about unknown quantities

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The recognition heuristic is a decision strategy that relies on explicit recognition memory. We argue that conceptual implicit memory cannot account for our findings (Rosburg *et al.*, 2011) and is also too limited to account for the midfrontal old/new effect (FN400), which, in our view, is a multiply determined familiarity-related brain signal.

Heuristics are decision rules that allow fast and frugal decisions in complex environments. The recognition heuristic is a memory-based strategy stating that, whenever two objects have to be ranked according to a criterion, the recognized object has a higher value with respect to this criterion [1–3]. How can one determine whether subjects actually rely on 'mere recognition', however [2], and not on other kinds of information? To address this issue, we recorded event-related potentials (ERPs) while participants performed a city-size comparison task [1]. We promoted use of the recognition heuristic by always pairing a well-known with a largely unknown city name. We were able to predict participants' decisions on the basis of a brain signal recorded between 300 and 450 ms after stimulus onset. This is a remarkable finding for the following reasons. In its topographic and temporal characteristics, this brain signal resembled the midfrontal old/new effect (FN400), an ERP effect associated with familiarity-driven recognition. By this, our findings support the view that the recognition heuristic relies on an early explicit memory process. As the memory processes underlying the recognition heuristic have not been explicitly examined to date [2], our results add to the increasing number of studies showing that neuroimaging data can constrain and validate psychological models.

In their comment, Paller *et al.* acknowledge the merits of our approach, but criticize a familiarity interpretation of the FN400 effect, relating this component to conceptual implicit memory instead. They state that the FN400 only correlates with familiarity under restricted circumstances, when conceptual implicit memory closely co-varies with familiarity. Paller *et al.* thus propose that conceptual implicit memory rather than familiarity is reflected in the FN400 and contributes to the decisions in the city-size comparison task. We argue here that this claim is not sufficiently substantiated.

Paller and colleagues have previously maintained that familiarity and conceptual priming should be differentially affected by some but not all experimental factors [4]. This is a valuable point to reiterate, but, by this same line of reasoning, there are a number of extant data points that challenge the position that the FN400 indexes implicit conceptual priming: retrieval intention should not affect implicit conceptual priming. Yet, an FN400 effect was observed when participants had to explicitly retrieve, but not when an implicit task was performed [5]. Retrieval orientation should not affect implicit conceptual priming. Yet, the FN400 was reported to co-vary with it [6]. Perceptual

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