Concept Paper

On Path Diagrams and the Neurophenomenal Field in Bilinguals

David William Green

Department of Experimental Psychology, Faculty of Brain Sciences, University College London, London WC1E 6BT, UK; d.w.green@ucl.ac.uk

Abstract: Conversation is a major site for our use of language. Each conversation elicits a distinct subjective experience: a specific and dynamic phenomenal field, and it is this field that controls our communicative actions. We cannot hope to understand the neural bases of conversation without relating these to the phenomenal field. We need a neurophenomenology of the bilingual speaker. I propose and illustrate an approach involving path diagrams together with retrospective experience sampling to capture the richness of the phenomenal field as a speaker talks through an issue of concern, and relate this process to large-scale attentional networks. The proposal offers a general approach to developing a neurophenomenology of the bilingual speaker and listener.

Keywords: path diagrams; neurophenomenology; neurophenomenal field; language attrition; mental simulation; counterfactual thinking; attentional networks; retrospective experience sampling

1. Introduction: Rationale and Setting the Scene

An important goal of research in bilingualism is to understand the linguistic and cognitive processes involved in language use, and that entails understanding such processes in a key site of language use: conversation. We talk to others to share our thoughts and feelings about different topics and so express our lived, subjective experience about them. This subjective or phenomenal experience is important if we are to make sense of the neural bases of language use, as revealed by analyses of the neural networks involved. How can we tell just by observing the dynamics of neural activity as a person looks at a film or talks about an episode in their lives what the neural flows of activity actually signify, without knowing what they are actually thinking or feeling? Linking the phenomenal and the neural domains is an exercise in neurophenomenology, a term coined by Varela (1996), and is an exercise vital to further our understanding of the nature of human consciousness. Its purpose is to connect the study of the structure of human experience, as in the work of the phenomenologists such as Merleau-Ponty (1964), with research that examines the dynamics of brain activity. This exercise is vital too for the narrower project of understanding the neural basis of language use in bilingual speakers.

Consider a small thought experiment. Suppose, hypothetically, we record neural activity as a bilingual speaker narrates an experience in her first language, and then ask that she retell it in her second language. How might we explain a dramatic increase in the activation of networks mediating affect in the latter case when we know from self-reports that words or phrases in a non-native language may lack affective charge and lead to a misconstrual of the significance of the utterance for the addressee (Pavlenko 2017), and that current experimental research suggests that talking in a second language may increase emotional distance from an event (e.g., individuals may be more utilitarian in their decisions (Costa et al. 2014))? Well, for some bilingual speakers, the disconnect between their lived experience and the felt capacity of the language they are currently using to express it induces a real sense of frustration, and even anger (e.g., Wierzbicka 2004). If, after the recording, we actually ask the speaker what they were thinking or feeling at different
moments in time, we are in a position to develop an explanation. Particularly poignant examples of disconnection arise when children become attriters in the language of their parents. I make use of one reported example of such attrition to illustrate how we might bring subjective experience into our theorizing and experimental research, and so afford a deeper understanding of the neural bases of language use during conversation between bilingual speakers. In the next section I overview the approach before then detailing the case study.

Our experience of the world is integrated, multi-modal and situated from a first-person point of view: a centered spatial structure or phenomenal field. Its point of origin, at least for sighted individuals, is experienced behind the eyes. It is sustained as we act in the world and engage with others. It allows us to envisage other points of view. For example, it allows us to envisage the hidden parts of objects so that we can act appropriately (e.g., I see just one side of a pot, not its hidden side, but infer it and so grasp it appropriately). It also allows us to envisage the points of view of other agents in our world, and so is a grounding for intersubjectivity and our ability to attribute mental states to others (e.g., Wiliford et al. 2018). The perspectival properties of the phenomenal field are therefore essential to our ability to act in the world. My interest is with its corollary—its psychological characterization. It is distinct, as personal experience attests—we can look out on the world as we walk, for example, and be somewhere else in our thoughts.

Psychologically, for the purposes of this paper, the focus of the phenomenal field is a current issue of concern (a particular topic) with a periphery of factors that bear on it. The core idea is that its more detailed structure can be expressed as a path diagram connecting together factors that we deem relevant to the issue of concern. Such diagrams have been used to understand how individuals perceive a wide range of issues (e.g., the risk and prevention of coronary heart disease (Green and McManus 1995); the causes of unemployment and employment (Green et al. 1998); the causes of overfishing (Nikolic and Lagnado 2015)) and have been used in formal analyses identifying causal factors in numerous phenomena (Pearl 2000; Pearl and Mackenzie 2018). Here I propose such diagrams as a means to capture the psychological relations involved in the phenomenal field as a precursor to mapping these onto the neural substrates to capture the neurophenomenal field.

The paths in the diagram reflect our understanding of which factor can affect which other factors based on our interactions with our physical, cultural and interpersonal worlds. Such understanding is captured in the notion of a mental causal model (e.g., Craik 1943; Green 1997, 2001; Johnson-Laird 1983, chp. 15; Pearl 2000; Pearl and Mackenzie 2018) that may be intersubjectively shared within a community. Our models are generative and we use them to explain, predict and control experience. For instance, in the case of the interpersonal world, we can ask why did someone speak as they did? Further, we can answer it: Why did John argue with Mary? Because she voted for someone he disliked. One or other party can intervene and defuse the argument by agreeing to disagree. Such questions, answers and interventions are possible because our models express relations amongst relevant factors, including their causal relationships. We also hold models of ourselves expressed in the narratives we use as we interact with others to make sense of our past and give meaning to our future (Mead 1959; and see also Andersen et al. 2020, for the important narratives in the context of social action).

Whilst our models of our physical, cultural and interpersonal world underlie our perceptions and attributions, our phenomenal experience at some moment in time arises from our current concerns: the cognitive–affective nexus. This is the psychological focus of the phenomenal field. Talking about it (or reflecting on it) creates further structure in terms of the paths linking different factors to the cognitive–affective nexus. The paths themselves are an outcome of our own personal memories, and the possible futures we envisage are intimately related to whom we consider ourselves to be. As we will see in the illustration, “loving daughter” is a salient theme of the personal narrative, and is an important driver of transformation in the phenomenal field. The approach here makes evident that our
phenomenal worlds mediated by language are permeated by imaginary and not simply by actual worlds.

In the illustration, I envisage that after talking about the specific concern to a friend, the participant constructs the path diagrams and also describes her thoughts and feelings at different points in time during the conversation. It is then the job of the researcher to code utterances in terms of the network of paths they reflect, and their experiential qualities, and analyze the neural dynamics coincident with the coded speech acts. I will say a little more about how we might construe that complexity in Section 2.3, but first I explore the illustrative case.

2. An Illustrative Case

Consider a familiar story: the life worlds of families migrating to a country whose main language (or lingua franca) they do not speak—Cantonese speakers, for instance, who migrate to America. A local community, whose language the parents speak, may support them and they thrive with hard work. Unsurprisingly, parents want their children to enjoy a better life with more material advantages than themselves. They muster an education for them so they become proficient in the dominant language (English, in the illustration). Some children as they grow older perhaps continue to live within the local community and function as language brokers with respect to the wider society. Others, with progressive mastery of English and the opportunities arising from their education, move away, identify themselves as members of American culture (assume an American identity) rather than as members of their parents’ diaspora, and become attriters in their first language. The salient issue here is the practical and affective communicative rupture experienced by a hypothetical young woman in the circumstances described by Liao (2021): in conversation with her parents, she is no longer fluent in Cantonese, and they speak no English.

2.1. The Path Diagrams

Imagine if you will the rich data recorded as our participant describes her thoughts and feelings in conversation with a friend. She first talks about how she has been feeling. She expresses awkwardness at having to use a translation app as she tries to find a Cantonese word or expression, regret at the loss of Cantonese, a sense of loss of her childhood, despite the sudden recall of specific childhood memories or a felt remembrance of childhood (see Sheldon et al. 2019, for this distinction). Then in a second part of the conversation, she talks about what she has decided to do as a result of a felt recognition that parents do not live forever. Her interventions are to relearn Cantonese and to envisage a new sense of self: a Cantonese–American identity. She anticipates a transformation in her lived experience. Awkwardness in conversation now becomes part of a joint project with the parents to relearn Cantonese—an exercise, at least initially, in translanguaging perhaps (Wei 2018). She sees it is possible to laugh about the process with her parents as she reaches for her translation app once more (see Appendix A) indicates the kind of change required to accommodate such a joint endeavor in an existing hierarchical control model of speech production and comprehension. The decision to form a new Cantonese–American identity becomes the intimation of a new self-narrative grounded in shared memories elicited through conversation and parental recollections—a richer intersubjectivity.

After the first part we ask her to draw a path diagram of the factors as she sees them that contribute to her salient concern—the focus of the phenomenal field (the cognitive and affective nexus). She draws Figure 1a. In this figure we see that she attributes attrition in Cantonese to her proficiency in English. Reduced Cantonese proficiency makes her interaction with her parents more difficult, both cognitively and emotionally. In the diagram, increased English proficiency contributes to an assimilation into American culture and identity, but suppresses identity based on Cantonese heritage. This too is seen as having a negative impact. It is important to note that the diagram can express relations that are not expressed in talk, but are in the phenomenal field. After the second part, she draws Figure 1b. Here two distinct but interlinked interventions are envisaged: relearning...
Cantonese and forging a new self-identity. The estimated effect of relearning Cantonese is to improve the quality of the interaction with the parents as Cantonese proficiency improves. Any such improvements yield a happier state. The second intervention, namely, the goal to create a new self-narrative based on a Cantonese–American identity, helps to integrate her life story to date.

These two diagrams are snapshots of the principal relations of factors involved and so “arrest” the dynamical flow of experience. A comparison of the two snapshots provides an indication of the change in the phenomenal field arising out of the two interventions. Indeed, at the path level, the transition between the two snapshots depicts the (psychological) flow of the phenomenal field. Essentially formerly negative paths become positive (e.g., the path from Cantonese proficiency to the interaction with parents) or are deleted (e.g., the path from American identity to Cantonese identity), or become contributory to a novel factor (e.g., Cantonese identity to Cantonese–American identity). The flow arises from the process of resolving the cognitive–affective nexus: reflecting on the issue of concern drives the transformation.

2.2. Conversation, Path Diagrams and Cognitive–Affective and Linguistic Processes

In this part I consider the gist of the talk between our language attriter and her friend as she considers the communicative rupture with her parents and resolves to do something about it. The goal is to conjecture the cognitive–affective and linguistic processes involved as they relate to the paths in the diagrams before, in the following section, relating these to their neural bases.

Her utterances, capturing paths in the diagram, sometimes take the form of an argument comprising a claim and a reason (e.g., I will feel better because I am able to talk to them) or may issue as conditional statements (e.g., If I acknowledge my heritage I will feel whole). Such arguments arise primarily out of thinking counterfactually (i.e., if only I had . . . or, if I were to . . . ). Cognitively, such thinking is a type of mental simulation and underlies emotions such as regret, wherein we envisage a better outcome if we had acted differently. In fact, we may choose actions that minimize anticipatory regret. We do so by placing ourselves in a hypothetical circumstance and mentally simulate alternative courses of action that lead to a preferred outcome. This yields an argument for action and provides
the basis for responding to a question as to why we are intending to act in a particular way (cf.: Billig 1987; Green 2011; Vygotsky 1981).

My construal takes mental simulation as the core process, with a number of phases nested under it corresponding to separate stretches of talk as per the text. It is this mental simulation that captures the flow of the phenomenal field. I consider the talk (indicated in italics and not intended as vernacular) and offer a gloss of the main cognitive and affective processes involved (in bold and in brackets). These glosses are high-level descriptions and are intended as indicative and simplifying. For example: (imagine possible world) covers both counterfactual “if only … “and semi-factual “even if … “ thinking. The outcome of thinking counterfactually is the interventions to relearn Cantonese and to construct a new self-narrative. The gloss (self-reflection) includes the retrieval and use of autobiographical memories. The gloss (affective attribution) covers love, regret, blame and exoneration. Such attribution is a necessary part of thinking counterfactually, but the gloss allows a separate reference. These high-level glosses are combined on occasion to emphasize the relative weight of a process. A gloss at the beginning of a paragraph indicates the main process of the phase and, for simplicity’s sake, ones at the end reference the various processes nested under it. The text in normal font that follows references the paths identified.

2.2.1. Part 1 of the Conversation Figure 1a Refers

Well I think about my interactions with my parents (self-reflection): I feel an emotional distance because I hardly speak Cantonese anymore and have to use a translation app. Look I know they love me and know that they know I love them. I have become distant from my Cantonese heritage as I’ve assumed an American identity (affective attribution, mental state attribution nested under self-reflection)

These utterances reflect the paths in Figure 1a to do with Cantonese proficiency and its impact both on her conversations with her parents, and her sense of identity as a loving daughter.

Am I to blame for this intersubjective rupture? I remember times when I was horrid to my parents and rebuked them: why had they never learned English? (self-reflection) and then think: if only I had maintained fluency in Cantonese but then (as a counter-argument) they wished me to speak English fluently and are proud of me and I am proud of myself too (imagine possible world, affective attribution, mental state attribution nested under self-reflection)

These utterances justify the inhibitory path between English proficiency and attrition in Cantonese and address the emotional complexity involved.

2.2.2. Part 2 of the Conversation Figure 1b Refers

Well you know with the pandemic and all, I started to think. Is there a way forward out of this unhappy state? (imagine possible world)

I could let matters go (imagine possible world) but I don’t want to be a stranger to them (self-reflection). If I were to do nothing I will regret it (affective attribution).

Is there something I could do that will be better for myself and my parents?

These utterances refer back initially to the state of affairs depicted in Figure 1a, and then look forward paths (interventions) in Figure 1b that could alter the cognitive–affective nexus for the better.

A: I will relearn Cantonese (imagine possible world): I think that I can improve my Cantonese. I know I can persevere (metacognitive processing) and if I do so it’ll make talking to my parents so much better.

And even if I do not succeed I will have tried and they will know it and that is a solace and no occasion for self-blame (metacognitive processing, affective attribution, mental state attribution nested under imagine possible world).
These utterances refer to a path emanating from the cognitive–affective nexus to a novel factor (relearning Cantonese) that enhances her interactions with her parents via a path coming from increased proficiency in Cantonese, and so helps resolve the issue of concern. They do not express the deletion of the negative path from English proficiency to Cantonese proficiency. Psychologically, though, this deletion signals a lack of opposition in her mind to the use of the two languages. In actual language use, given dual language activation, there will be an increased need for language control (see Kroll et al. 2015, for a review). The psychological value of the intervention is that it transforms her interactions with her parents and her future anticipated recollection of it.

B. I will recognize my Cantonese heritage: I built an American identity at a cost of my personal history (self-reflection). But if I work on my Cantonese heritage (e.g., my parents’ life histories and culture) I do not want it to be in conflict with my American identity I will create a new Cantonese-American identity (imagine possible world nested under self-reflection).

These utterances refer to a driving input from the cognitive–affective nexus to a novel factor—an imagined Cantonese–American identity in which her American identity no longer suppresses her heritage identity, but together with it contributes to a to-be-created identity. The path diagram also indicates something that is not directly expressed, that forging the new identity is envisaged to resolve the concern and also improve her interactions with her parents. Their life histories are a way for her to learn about her heritage, but also such conversations may well ground or embody her learning of Cantonese just as the initial learning of a language is learning a habit of conduct (Merleau-Ponty 1964).

2.3. The Neurophenomenology of Resolving the Cognitive–Affective Nexus

Neural dynamics can be captured at multiple scales, both spatial and temporal, reflecting self-organizing networks. Naming the coordination of regions as networks tuned to certain functions does not imply that the regions involved are specialized for such a function any more than the so-called word form area is specialized for word recognition. The functional profile of a region depends on the full set of its interconnections (Price and Friston 2005). The high-level descriptions likely cover a range of component processes, and so only detailed task comparisons may delimit the functional profile. However, it is convenient, and least tendentious here, to map the high-order process descriptions such as mental simulation to large-scale attentional networks. Table 1 references research that has associated the mental processes, such as mental simulation, that I have identified in the construction of the paths in the path diagrams with such large-scale networks or neural regions.

If the construal offered here is correct, there is analytic complexity to any analysis of neural data. The construal implicates a hierarchy of control in which one process is nested, at least transiently, within another (see also Green 2019). For example, in holding a conversation, we need to sustain attention on that goal whilst also calling on different networks as we change topics of conversation from talking about a shared external current scene to reporting a memory. Here nested under the goal to sustain attention to conversation, the attentional network mediating mental simulation, for example, must be sustained over some duration, as other networks and regions are coopted for other purposes. At a minimum, whilst perceptual and sensory processing continues, this entails that a network engaged in the fulfilment of some external task (e.g., the dorsal attentional network, DAN) is down-regulated or suppressed, at least temporarily, to allow internally focused attention to act. The default mode network (DMN) mediates such attention and its recruitment coincides with an increase alpha oscillation over parietal regions consistent with the suppression of DAN (e.g., Higgins et al. 2021). The DMN forms a core network for mental simulation and counter-factual thinking that is crucial to feelings of regret or self-blame (as expressed in her talk), and also in identifying suitable interventions. Such thinking requires distinguishing the present world from the imagined world, and is postulated to require a fronto-parietal and a cingulo-opercular network for its control (see van Hoeck...
et al. 2015). It also involves recruiting regions or networks that offer grounds for believing in the effectiveness of an intervention. Part of the reason she gives for undertaking to relearn Cantonese is the confidence she feels in her ability to persevere. Such a feeling is metacognitive and is associated with computations in rostral and dorsal prefrontal regions (Fleming and Dolan 2012).

Table 1. Resolving the cognitive–affective nexus: mapping to large-scale attentional networks.

| High-Order Process       | Neural Networks and Regions     | Example References          |
|-------------------------|---------------------------------|-----------------------------|
| mental simulation       | DMN                             | Raichle (2015)              |
| self-reflection          | DMN                             | Sheldon et al. (2019)       |
| imagine possible world   | DMN, PCC, mPFC                  | Johnson et al. (2002)       |
| affective attribution    | amygdalae – basal ganglia       | van Hoeck et al. (2015)     |
| mental state            | right dlPFC                     | Cohen-Zimerman et al. (2021)|
| meta-cognitive processing| rostral and dorsal PFC          | Fleming and Dolan (2012)    |

Key: DMN default mode network; FPC fronto-parietal control network; C-O C cingulo-opercular control network; AI anterior insula; PFC prefrontal cortex; PCC posterior cingulate cortex; dlPFC dorsolateral prefrontal cortex; mPFC medial prefrontal cortex; vmPFC ventromedial prefrontal cortex; mOFC medial orbito frontal cortex; plOFC posterior lateral orbito-frontal cortex.

At the heart of the present proposal is the driving role of affect. Affective processing is integral as it instigates the search for a preferred state (via mental simulation) and selects actions that plausibly lead to that state. van Hoeck et al. (2015) refer to an emotion and value processing network. It is the one mediating affective attribution and connects the amygdalae, striatum and frontal cortices, and in the proposal here is core to the cognitive–affective nexus and the drive to identify options expressed in the pathways of the path diagram to resolve a personal state of unhappiness. If this proposal has merit then it is reasonable to expect this network of regions to increase in activation as it provides a coordinating hub for identifying possible interventions. Such activation should then precede utterances that reference such interventions.

We can go further in our neurophenomenological approach. After the scan, we ask her what she was thinking and feeling at different moments in the scan. Retrospective experiential sampling of her experience at different time periods during the scan can deepen what can be inferred from her utterances (see Gonzalez-Castillo et al. 2021; Jääskeläinen et al. 2022; Jachs 2021, for discussion and use of such methods). We should expect retrospective sampling to reveal episodes of mental simulation subsuming periods of self-reflection and counterfactual thinking. Further, if she was asked to trace the felt psychological importance over successive time intervals (see Jachs 2021, for such a method) we might find high importance to be associated with the explicit recall of autobiographical memories under the dominance of the default mode network. Conceivably, as proposed above, the affective network is the primary driver of episodes in which she considers possible interventions, and so should precede episodes where she identifies the proposed interventions.

Analytically, the need is to explore the transient and flexible reorganization and coordination of the various neural networks implicated. Fortunately, researchers are actively exploring techniques such as Hidden Markov modeling to do so (e.g., Chen et al. 2017), which can be applied to both magnetoencephalography data (Tibon et al. 2021) as well as to functional magnetic resonance imaging data (Quinn et al. 2018).
2.4. Further Tests and Predictions

I considered above how to explore the neurophenomenal field of our hypothetical attriter as she talked with a friend about the communicative rupture with her parents. Testing the proposal in this way may seem a promissory note if it involves full multimodal recording including body movement, facial expression and hand gestures, though that prospect may not be too far distant for certain neural-based signals, as wearable optically pumped magnetometers provide fine multichannel sensitivity for magnetoencephalography systems (e.g., Tierney et al. 2019). In this section I consider other ways to make use of the perceived structure of the phenomenal field together with retrospective experience sampling, and relate it to its neural basis.

We talk not only to others but to ourselves. Self-talk engages parts of the language-sensitive networks too (e.g., Jones and Fernyhough 2007; Grandchamp et al. 2019; Barber et al. 2021), and can concern all manner of topics. On the basis of such research, we can perform a type of resting state scan with our attriter. We ask her to silently think about and think through the issue of concern. After the scan, as previously, she draws a path diagram of the factors she considered important with its focus (the cognitive–affective nexus), and indicates how that diagram changed in the light of the intervention to relearn Cantonese and to forge a new sense of identity. Then, we make use of retrospective sampling to enhance our mapping from the subjective to the neural.

I have explored the value of path diagrams in understanding the neurophenomenal field of a hypothetical bilingual speaker. The approach can be extended with a novel between-subject protocol. We can ask bilingual speakers with common experiences and those from different community backgrounds and experiences to construct path diagrams with respect to a key issue of concern for them as bilingual speakers (see Beatty-Martínez et al. 2020, for the value of comparing bilingual speakers from different backgrounds in understanding behavioral data). Now, we record their neural responses as they listen to the narrative of our language attriter. We know from prior research that neural responses between speaker and listener couple or align most closely when listeners comprehend what is being said (Stephens et al. 2010; Liu et al. 2017). Under the novel protocol, we use path diagrams to predict time periods in the narrative that may have the most direct relevance to each individual, i.e., we predict periods of heightened cognitive–affective response. We can test these predictions by asking listeners retrospectively to profile their reactions at different time periods (e.g., as per Jachs 2021), and coordinate these with respect to their individual neural response. Under this type of protocol, the idea would be to examine whether or not the variety of neural response across participants as they listen to a common narrative can be explained by the phenomenal characterization of their personal bilingual histories. Studies of this type explore the neurophenomenal fields of different bilingual speakers.

3. Review: Characterizing the Neurophenomenal Field

The neural bases of language use in conversation between bilinguals will remain opaque to understanding until we capture the subjective experiences of the participants as well—we need to understand the neurophenomenal field. This paper proposes that we can use path diagrams (see Figure 1a,b) to capture the psychological structure of the phenomenal field: its cognitive–affective nexus (the focus), and the important factors and their path interrelations that bear on it. Such diagrams, together with further path qualities yielded by retrospective experience sampling, can inform the mapping between subjective experience—the flow of the phenomenal field—and its neural bases.

This paper has illustrated the approach by considering the neurophenomenal field of a hypothetical bilingual speaker reflecting on a matter of cognitive and affective significance for her in two contexts: one as she talked to a friend and a second as she thought about it silently. The matter of concern (the topic) was that she was an attriter in Cantonese, the language of her parents, and they spoke no English—a language in which she was proficient. Her path diagram indicated that by relearning Cantonese and forging a new self-identity (a Cantonese–American identity), she could resolve the cognitive–affective nexus. I treated
mental simulation as a fundamental process in envisaging an alternative state of affairs from the present, and allowed the nesting of other processes (e.g., ones linked to the retrieval of personal memories) within it. By mapping such processes to high-level attentional network (such as the default mode network), it is possible to conjecture the neural bases of her talk. Retrospective experience sampling after the scanning allows such conjectures to be tested and refined. A third context envisaged bilinguals from either a common or a distinct background listening to her talk. Using the same basic procedures (path diagrams, retrospective experience sampling) allows assessment of the neurophenomenal fields of different bilingual speakers in response to an identical input.

Path diagrams aim to capture the psychological factors and their relations, as perceived by the bilingual, that bear on a key issue. The subjective flow of the phenomenal field is induced by resolving the cognitive–affective nexus through an intervention. It is a driving vector that can alter the polarity of the relations in the field—changing a negative relation, for example, to a positive one. Interventions issue in particular kinds of utterance (e.g., If I do X then Y will follow), and reflect the individual’s understanding or model of their world. Which kinds of interventions are considered are likely to depend not only on the polarity of the relations expressed in the path diagram, but also on their strength. The strength of a relation may commend it as a candidate intervention likely to have the greatest impact. Retrospective experience sampling, I have suggested, is a way to profile the likely multidimensional nature of the paths, and so amplify our ability to capture the neurophenomenal field. Other methods, involving more detailed enquiry with actual speakers (e.g., using Interpretative Phenomenological Analysis—Smith et al. 2009) may reveal phenomenological fields of greater complexity. The empirical question is then the extent to which the increased richness derived from such methods further enhances the explanation of the neural dynamics. It would also be valuable to have a more formal characterization of subjective experience in order to explore this question. The pioneering work of Székely (1965) offers a possible formalism for capturing the affective and cognitive content of inner experience.

Perhaps it goes without saying that just because a speaker recognizes a matter of concern does not entail that they wish to do anything about it. That decision depends on their stance with respect to the issue. Self-talk may yield acceptance of the state of affairs (che sera, sera). For the hypothetical individual, I considered such a stance was not part of the narrative of herself.

I illustrated a neurophenomenal approach with respect to a particular topic related to language use in a speaker who was an attriter in the language of her parents. Such diagrams also offer a way to identify individual differences in the subjective demands of learning a language later in life. Consider the urgent demand to learn a new language experienced by refugees from war living in a new culture. Such a demand will strongly characterize the cognitive–affective nexus of their phenomenal field. Allowing individuals to depict the key psychological factors that they perceive as stressing and de-stressing offers a way to identify potential interventions to support their language learning. Such interventions (e.g., physical exercise; joint music-making) may not be directly related to language learning, but directed at reducing the effects of stress on the network of cortical and subcortical regions involved in the cognitive control required for language learning (Green 2018; and see Sousa 2016, for a synoptic review of the effects of stress on the cortical and subcortical networks involved in cognitive control.) If successful, such efforts will be reflected in changes in the neurophenomenal field of such bilinguals.

Language concerns also arise for proficient speakers. As noted in the Introduction, a felt disjointedness when discussing feelings in one language rather than another may also merit an intervention in the phenomenal field (e.g., Wierzbicka 2004). In such circumstances, only a recognition of the fact of disjointedness may offer a way to circumvent irritation. Figure 2a,b below proposes an intervention in which the person shifts their pragmatic frame. When they use English, rather than their native tongue (Polish), they “act in English”, meaning that they feel but do not worry about the discrepancy in emotional
nuance, allowing for covering phrases such as “it’s not quite how I’m feeling” to signal this discrepancy. It would be interesting to know whether such reframing alters the neurophenomenology of language use.

![Diagram](image_url)

**Figure 2.** A frame shift intervention designed to accept the perceived incomparability of language use suffused by distinct cultural identities. (a) before the intervention, (b) after the intervention (please see text for exposition).

Depicting phenomenal fields in path diagrams is widely applicable beyond issues concerned with language use as such. Conversations cover a range of topics, and speakers may have a range of issues of concern that they wish to discuss. Understanding the neural basis of conversation between bilingual speakers requires not only tracking neural activity in language-eloquent networks and tracking the large-scale attention networks as different topics are covered (Green 2019), but also tracking the thoughts and feelings as such topics are discussed. Path diagrams together with experience sampling offer a way to do so.

In conclusion, and in line with Varela’s (1996) exhortation for the necessity of neurophenomenology in the study of human consciousness, I hope I have provided grounds for believing that with the use of path diagrams, on-line scanning and experience sampling, we can explore the neural bases of subjective states during conversations between bilingual speakers, ushering in a neurophenomenology of the bilingual speaker.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not Applicable.

**Informed Consent Statement:** Not Applicable.

**Data Availability Statement:** Not applicable.

**Acknowledgments:** I thank Judith Kroll and two anonymous reviewers for their comments on an earlier version of this paper.

**Conflicts of Interest:** The author declares no conflict of interest.
Appendix A

Figure A1. Mapping the speech act when a word or phrase is unknown in the target language (adapted from Green 2019).

Appendix A sketches the mapping of a speech act into overt speech in the context of conversation. It depicts the intimate relation between speech production processes and the comprehension of another’s speech and own speech. The intention to speak about a particular topic recruits knowledge represented in a conceptual domain, and drives the activation of lexical concepts and constructions in functionally separable language networks. Outputs from the networks are gated for entry into the planning process as per language control processes (see Green 2019, for further details). Where no word or phrase is available in the target language, and switching between languages is precluded because there is no shared language, the speaker uses an external translation app. The path indicated in Figure 1 is that app use is initiated once the monitoring circuits detects the problem. Output from the app becomes speech input that is mapped into the language network before release via the gate into the utterance plan.

References

Andersen, Ditte, Signe Ravn, and Rachel Thomson. 2020. Narrative sensemaking and prospective social action: Methodological challenges and new directions. International Journal of Social Research Methodology 23: 367–75. [CrossRef]

Barber, Liam, Renate Reniers, and Rachel Upthegrove. 2021. A review of functional and structural neuroimaging studies to investigate the inner speech model of auditory verbal hallucinations in schizophrenia. Translational Psychiatry 11: 582. [CrossRef]

Beatty-Martínez, Anne L., Christian A. Navarro-Torres, Paola E. Dussias, Maria Teresa Bajo, Rosa E. Guzzardo Tamargo, and Judith F. Kroll. 2020. Interactional context mediates the consequences of bilingualism for language and cognition. Journal of Experimental Psychology: Learning, Memory, and Cognition 46: 1022–47. [CrossRef]

Billig, Michael. 1987. Arguing and Thinking: A Rhetorical Approach to Social Psychology. Cambridge: Cambridge University Press.

Chen, Jingyuan E., Mikail Rubinov, and Catie Chang. 2017. Methods and considerations for dynamic analysis of functional MR imaging data. Neuroimaging Clinics of North America 27: 547–60. [CrossRef]

Cohen-Zimerman, Shira, Harsh Khiwani, Gretchen N. L. Smith, Frank Krueger, Barry Gordon, and Jordan Grafman. 2021. The neural basis for mental state attribution: A voxel-based lesion mapping study. Human Brain Mapping 42: 65–79. [CrossRef] [PubMed]

Craik, Kenneth. 1943. The Nature of Explanation. Cambridge: Cambridge University Press.

Costa, Albert, Alice Foucart, Inbal Arnon, Melina Aparici, and Jose Apesteguia. 2014. “Piensa” twice: On the foreign language effect in decision making. Cognition 142: 236–54. [CrossRef] [PubMed]

Fleming, Stephen M., and Raymond J. Dolan. 2012. The neural basis of metacognitive ability. Philosophical Transactions of the Royal Society B 367: 1338–49. [CrossRef] [PubMed]

Gonzalez-Castillo, Javier, Julia W. Y. Kam, Colin W. Hoy, and Peter A. Bandettini. 2021. How to interpret resting-state fMRI: Ask your participants. Journal of Neuroscience 41: 1130–41. [CrossRef] [PubMed]
Grandchamp, Romain, Lucie Rapin, Marcela Perrone-Bertolotti, Céline Pichat, Céline Haldin, Emile Cousin, Jean-Philippe Lachaux, Marion Dohen, Pascal Perrier, Maëva Garnier, and et al. 2019. The ConDialInt Model: Condensation, Dialogality, and Intentionality dimensions of inner speech within a hierarchical predictive control framework. *Frontiers in Psychology* 10: 2019. [CrossRef]

Green, David W. 1997. Explaining and envisaging an ecological phenomenon. *British Journal of Psychology* 88: 199–217. [CrossRef]

Green, David W. 2001. Understanding microworlds. *Quarterly Journal of Experimental Psychology* A 54: 879–901. [CrossRef]

Green, David W. 2011. Arguments in mind. In *Science of Reason: A Festschrift for Jonathan St.B.T. Evans*. Edited by Ken Manktelow, David E. Over and Shira Elqayam. Brighton: Psychology Press, pp. 53–61.

Green, David W. 2018. The interactive challenge: L2 learning and use in the third age. In *Third Age Learners of Foreign Languages*. Edited by Danuta Gabryś-Barker. Bristol: Multilingual Matters, chp. 3. pp. 31–47.

Green, David W. 2019. Language control and attention during conversation: An exploration. In *The Handbook of the Neuroscience of Multilingualism*, 1st ed. Edited by John W. Schwieter. Hoboken: John Wiley & Sons Ltd., chp. 21. pp. 427–46.

Green, David W., and Ian C. McManus. 1995. Cognitive structural models: The perception of risk and prevention in coronary heart disease. *British Journal of Psychology* 86: 321–36. [CrossRef]

Green, David W., Ian C. McManus, and Jay Derrick. 1998. Cognitive structural models of unemployment and employment. *British Journal of Social Psychology* 37: 415–38. [CrossRef]

Higgins, Cameron, Yunzhe Liu, Diego Vidaurre, Zeb Kurth-Nelson, Ray Dolan, Timothy Behrens, and Mark Woolrich. 2021. Replay bursts in humans coincide with activation of the default mode and parietal alpha networks. *Neuron* 109: 882–93. [CrossRef]

Jääskeläinen, Iiro P., Jyrki Ahveninen, Vasily Klucharev, Anna N. Shastakova, and Jonathan Levy. 2022. Behavioral experience sampling methods in neuroimaging studies with movie and narrative stimuli. *Frontiers of Human Neuroscience* 16: 813684. [CrossRef]

Jachs, Barbara. 2021. The Neuropsychophenomenology of Meditative States: Introducing Temporal Experience Tracing to Capture Subjective Experience States and their Neural Correlates. Doctoral thesis, University of Cambridge, Cambridge, UK. [CrossRef]

Johnson, Sterling C., Leslie C. Baxter, Lana S. Wilder, James G. Pipe, Joseph E. Heiserman, and George P. Prigatano. 2002. Neural correlates of self-reflection. *Brain* 125: 1808–14. [CrossRef][PubMed]

Johnson-Laird, Philip N. 1983. *Mental Models: Towards a Cognitive Science of Language, Inference and Consciousness*. Cambridge: Cambridge University Press.

Jones, Simon R., and Charles Fernyhough. 2007. Neural correlates of inner speech and auditory verbal hallucinations: A critical review and theoretical integration. *Clinical Psychological Review* 27: 140–54. [CrossRef]

Kroll, Judith F, Paola E. Dussias, Kinsey Bice, and Lauren Perrotti. 2015. Bilingualism, mind, and brain. *Annual Review of Linguistics* 1: 377–94. [CrossRef]

Liao, Jenny. 2021. Forgetting my first language. *The New Yorker*, September 3. Available online: https://www.newyorker.com/culture/personal-history/forgetting-my-first-language (accessed on 5 October 2022).

Liu, Yichuan, Elise A. Piazza, Erez Simony, Patricia A. Shewokis, Banu O naral, Uri Hasson, and Hasan Ayaz. 2017. Measuring speaker–listener neural coupling with functional near infrared spectroscopy. *Scientific Reports* 7: 43293. [CrossRef]

Mead, George H. 1959. *The Philosophy of the Present*. La Salle, IL: Open Court.

Merleau-Ponty, Maurice. 1964. *The Primacy of Perception*. Evanston, IL: Northwestern University Press.

Nikolic, Milena, and David A. Lagnado. 2015. There aren’t plenty more fish in the sea: A causal network approach. *British Journal of Psychology* 106: 564–82. [CrossRef][PubMed]

Pavlenko, Aneta. 2017. Do you wish to waive your rights? Affect and decision-making in multilingual speakers. *Current Opinion in Psychology* 17: 74–78. [CrossRef][PubMed]

Pearl, Judea. 2000. *Causality: Models, Reasoning and Inference*. Cambridge: Cambridge University Press.

Pearl, Judea, and Dana Mackenzie. 2018. *The Book of Why: The New Science of Cause and Effect*. New York: Basic Books.

Price, Cathy J., and Karl J. Friston. 2005. Functional ontologies for cognition: The systematic definition of structure and function. *Cognitive Neuropsychology* 22: 262–75. [CrossRef]

Quinn, Andrew J., Diego Vidaurre, Romesh Abeysuriya, Robert Becker, Anna C. Nobre, and Marli W. Woolrich. 2018. Task-evoked dynamic network analysis through Hidden Markov modelling. *Frontiers in Human Neuroscience* 12: 603. [CrossRef]

Raichle, Marcus E. 2015. The brain’s default mode network. *Annual Review of Neuroscience* 38: 433–47. [CrossRef][PubMed]

Sheldon, Signy, Can Fenerci, and Lauri Guruguryan. 2019. A neurocognitive perspective on the forms and functions of autobiographical memory retrieval. *Frontiers in Systems Neuroscience* 13: 4. [CrossRef]

Smith, Jonathan A., Paul Flowers, and Michael Larkin. 2009. *Interpretative Phenomenological Analysis*. London: Sage.

Sousa, Nuno. 2016. The dynamics of the stress neuromatrix. *Molecular Psychiatry* 21: 302–12. [CrossRef]

Spreng, R. Nathan, and Cheryl L. Grady. 2009. Patterns of brain activity supporting autobiographical memory, prospection, and Theory of Mind, and their relationship to the Default Mode Network. *Journal of Cognitive Neuroscience* 22: 1112–23. [CrossRef][PubMed]

Stephens, Greg J., Lauren J. Silbert, and Uri Hasson. 2010. Speaker-listener neural coupling underlies successful communication. *Proceedings of the National Academy of Sciences USA* 107: 14425–30. [CrossRef][PubMed]

Székely, Edmond. 1965. *Basic Analysis of Inner Psychological Functions*. *British Journal of Psychology, Monograph Supplements* (L. S. Hearnshaw, Ed.) XXXVII. Cambridge: Cambridge University Press.

Tibon, Roni, Kamen A. Tsvetanov, Darren Price, David Nesbitt, Can A. N. Cam, and Richard Henson. 2021. Transient neural network dynamics in cognitive ageing. *Neurobiology of Aging* 105: 217–28. [CrossRef]
Tierney, Tim M., Niall Holmes, Stephanie Mellor, José D. López, Gillian Roberts, Ryan M. Hill, Elena Boto, James L. Legett, Vishal Shah, Matthew J. Brookes, and et al. 2019. Optically pumped magnetometers: From quantum origins to multi-channel magnetoencephalography. *NeuroImage* 199: 598–608. [CrossRef]

van Hooek, Nicole, Patrick D. Watson, and Aron K. Barbey. 2015. Cognitive neuroscience of human counterfactual reasoning. *Frontiers in Human Neuroscience* 9: 420. [CrossRef]

Varela, Francisco. 1996. Neurophenomenology: A methodological remedy for the hard problem. *Journal of Consciousness Studies* 3: 330–49.

Vygotsky, Lev. 1981. The genesis of higher mental functions. In *The Concept of Activity in Social Psychology*. Edited by J. Wertsch. Armonk, NY: Sharpe, pp. 144–88.

Wei, Li. 2018. Translanguaging as a practical theory of language. *Applied Linguistics* 39: 9–30. [CrossRef]

Wierzbicka, Anna. 2004. Preface: Bilingual lives, bilingual experience. *Journal of Multilingual and Multicultural Development* 25: 94–104. [CrossRef]

Wiliford, Kenneth, Daniel Bennequin, Karl Friston, and David Rudrauf. 2018. The projective consciousness model. *Frontiers in Psychology* 9: 02751. [CrossRef]