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Forum

Narratives for Neuroscience

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People organize and convey their thoughts according to narratives. However, neuroscientists are often reluctant to incorporate narrative stimuli into their experiments. We argue that narratives deserve wider adoption in human neuroscience because they tap into the brain's native machinery for representing the world and provide rich variability for testing hypotheses.

Neuroscientists tell stories about the brain. They rarely, however, use stories to understand the brain. Narratives are the human brain's way of consolidating and conveying the temporally-evolving world we live in. Here we present four related reasons why stories (i.e., narratives) are a critical class of stimuli for neuroscientists. But first, what is a narrative?

Working Definition of Narratives for Neuroscientific Research

Here, we define narrative loosely as a discourse unit that includes events and one or more characters. The information contained in a narrative evolves such that our understanding of a given event often depends on other events in the narrative. Spoken and written stories, movies, and 'storified' journalism are paradigmatic examples of narratives.

A Case for Narratives as Essential Stimuli in Neuroscience

Narratives Make Cognition Easier

Jerome Bruner [1] famously argued that the 'narrative mode' is the way in which humans most easily receive and transmit information. Presenting information within a narrative context lightens cognitive load. A great example of this is the embedding of multiple mental states. Humans find this difficult outside of a narrative context but do it effortlessly within a narrative. Consider this example:

> 'I *know* that Ann *believes* that Peter *suspects* that Mary *realizes* that Bill *understood* that Will is a sailor.'

Figuring out who thinks what about whom is difficult in this sentence. This fits well with a literature showing that humans find it challenging to process multiple recursively embedded mental states. A narrative context turns this finding upside down. An analysis of Shakespeare's *Othello*, for instance, shows that the state of affairs in the play at a given point can be described like this [2]:

> 'The audience *believe* that Iago *intends* that Othello *imagines* that Desdemona *thinks* that Cassio is adorable.'

This state of affairs is hard to understand outside of a narrative context but much less so within the original play. Narrative structure provides a scaffold for representing complex relations among agents. Within a narrative, humans often do not find it difficult to understand embedded mental states (and – depending on the story and the storyteller – may even enjoy it). Not only does narrative context lighten cognitive load, it points us toward what our minds are good at.

Narratives Simulate Reality

Narratives reflect the real world. Narratives describe events and social interactions that, although we know are not necessarily real, can feel very realistic. Indeed, a core function of narratives is to provide a simulation of reality [3]. This means that narratives can be used to study a whole host of neural processes that cognitive neuroscientists are interested in; using narratives has already been extremely fruitful in some domains.

For example, since events described in narratives mimic real-world experiences, narratives have been fundamental to our understanding of how the brain structures events during perception and in memory [4]. In a seminal study [5], narratives were used to reveal a cortical processing hierarchy of temporal receptive windows. As experiences unfold, incoming information is structured into hierarchies [5] based on event segmentation at multiple, nested timescales (Figure 1) [6].

However, unlike reality, narratives can condense experiences by 'editing out' events (and conversely, they can expand the duration and detail of events). Furthermore, editing enables us to reveal factors that guide the organization of event representations in memory, such as simultaneous representation of event information in the hippocampus at multiple temporal resolutions – spanning several events [7] and even entire storylines lasting well over an hour [8].

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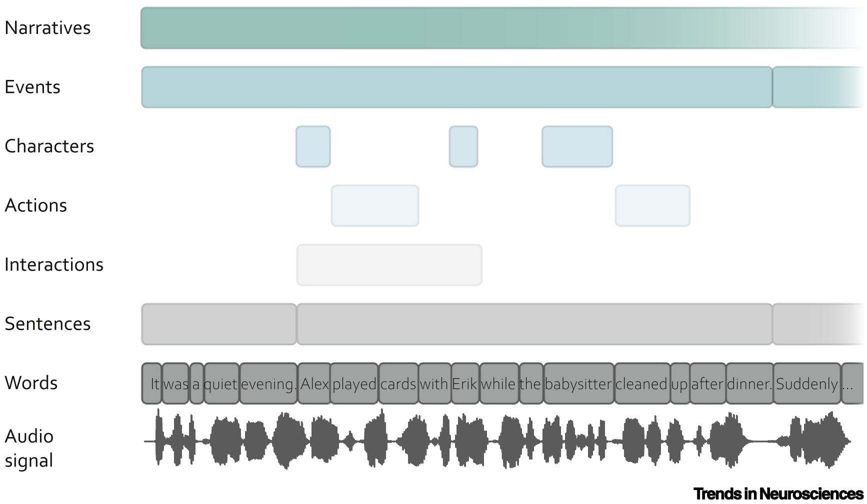

Figure 1. Narratives Comprise Many Layers of Nested Features. These features can for instance include (from bottom to top in the schematic): phonemes, words, sentences, social interactions, actions, characters, events, and narrative context. As such, narrative stimuli allow researchers to study a variety of cognitive and perceptual processes. Gradually emerging narrative context can modulate processing of individual embedded features; this kind of contextual modulation is absent from more traditional paradigms comprising strictly controlled and decontextualized stimuli. By leveraging narrative stimuli and computational models, neural mechanisms underlying cognitive processes for each feature of interest can be isolated during naturalistic experience. This approach can allow researchers to take a step toward generalizing their findings beyond the laboratory setting and can advance our understanding of how different cognitive processes interact during real-world experience.

Narratives Feature Rich Variation

In many ways, narratives are the antithesis of classical experimental stimuli, which are deliberately controlled, decontextualized, and stripped of temporal dynamics (e.g., by randomizing trial order). These characteristics have likely contributed to the slow adoption of narratives in neuroscience research. However, using narratives to study cognition does not mean that we lose all experimental control. Narratives can be developed or edited to feature the relevant conditions necessary for addressing the experimental questions of interest. One study, for example, investigated event integration by using short, tightly controlled five-event narratives [7].

Even with relatively well-controlled narratives, as in this example, narrative stimuli, unlike traditional experimental stimuli, often comprise many superimposed, intercorrelated variables (Figure 1). This apparent lack of experimental control presents both challenges and opportunities (Box 1). On the one hand, a narrative stimulus may have lower efficiency than a traditional experimental manipulation for testing a particular hypothesis if the relevant conditions occur infrequently in more naturalistic narrative contexts [9]. On the other hand, exploiting naturally occurring variation embedded in narrative stimuli will tend to yield more generalizable results. For instance, one study modeled word-by-word predictability in a narrative to better understand the neural basis of prediction during natural language comprehension [10]. Another benefit of narrative stimuli is that their richness can be used to simultaneously evaluate, and compare, multiple hypotheses. This allows researchers to better assess the relative contributions of different variables or features to neural responses under naturalistic conditions. Using modern computational models, researchers have turned this to their advantage, for example, for disentangling the neural machinery supporting perceptual and semantic processing [9,10]. Further, narratives are well suited to investigating both commonalities across participants [11] as well as idiosyncratic variation [12].

Box 1. In Defense of Narratives: Rebuttals to Common Arguments against the Use of Narratives in Neuroscience

'Narratives are not well controlled': Critics may argue that, experimentally, narratives often contain many confounding variables, making interpretation more difficult. Response: Narratives can be constructed or edited to emphasize a particular variable of interest. Furthermore, the ‘uncontrolled’ nature of narratives can be turned to an advantage. Respecting the statistical regularities of naturalistic contexts yields more ecologically valid results and allows research to evaluate the relative contributions of different variables (see Figure 1 in main text).

'Narratives are difficult to analyze': The seemingly ‘uncontrolled’ nature of narratives may make data analysis seem daunting. Response: Researchers have begun to develop methods for accommodating the richness of narrative stimuli. For example, methods for model comparison and variance partitioning allow researchers to evaluate the relative contributions of different features to neural responses [9]. Analytic tools can be shared online (e.g., https://brainiak.org/) to facilitate adoption in the community [6,11].

'Narratives are confounded with time': Narratives require integration of information over time, making it impossible to decouple any given event from past events. Response: Although narratives defy certain principles of experimental design (e.g., repeated exposure, trial averaging), we argue that this is a feature – not a bug – of narrative stimuli. Temporal context is a fundamental feature of cognition and paradigms that deliberately decontextualize stimuli do so at the expense of ecological validity.

'Narratives are too esoteric': Some researchers regard narratives as largely outside the scope of human neuroscience, seeing them as ‘niche’ or ‘contrived’ stimuli with poor generalizability. Response: Narratives often simulate the real world and are a naturally engaging stimulus. Indeed, narratives are constructed to interest the audience, making them optimal stimulants of the human mind. If the narrative mode is one of the cornerstones of human thought and communication, narratives should be considered an important experimental vehicle for understanding human cognition.

Narratives Promote Data Reuse

As a unifying stimulus across many domains of cognition, each narrative stimulus can

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inform multiple research questions [9]. Hypotheses developed for one narrative stimulus can often be validated on other narrative stimuli. For example, brain responses to a spoken story stimulus like 'Pie Man' by Jim O'Grady (https://themoth.org/stories/pie-man) can be used to evaluate and compare models of spectral, articulatory, and semantic content, models of event segmentation, as well as methods for functional network estimation (Figure 1) [6,9,11]. This high reuse value makes narrative paradigms an efficient FAIR (findable, accessible, interoperable, and reusable) research strategy (https://fair-research.org) with clear utility for open science.

The release and curation of public benchmark datasets holds tremendous benefits for both neuroscience and other fields (e.g., machine learning). The recently released 'Narratives' data collection [13] collates functional magnetic resonance imaging (fMRI) responses from over 300 subjects (comprising over 750 functional scans) spanning 28 different spoken narratives of varying length. The publication of large neuroimaging datasets, acquired while participants engage with narratives, opens up the possibility of leveraging large samples to validate models across subjects and stimuli. We hope to see an increasing number of public neuroscience datasets capitalizing on the richness of narrative paradigms in the coming years.

Outlooks

Early adopters of narratives for neuroscience research have introduced methods for stimulus development, data analysis, computational modeling, and sharing large datasets. However, some challenges still remain for a more complete acceptance of narratives in neuroscience research; namely, we need to more fully integrate knowledge from other fields, including the humanities, in order to develop more complete models of how the brain processes information presented within narrative context, and how narrative context modulates prior knowledge to form a nuanced interpretation of ongoing experience. What's more, narratives are a critical component of education, communication, and policymaking, and better understanding of the neural mechanisms underlying narrative processing will likely have wide societal ramifications.

Acknowledgments

R.M.W. was supported by a grant from The Netherlands Organization for Scientific Research (NWO Vidi 276-89-007). S.A.N. was supported by the National Institute of Mental Health under award number R01MH112566. B.M. was supported by The Netherlands Organization for Scientific Research 'Language in Interaction' Gravitation grant (024.001.006).

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https://doi.org/10.1016/j.tins.2020.03.003

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