

**Cognitive Correlates of Pragmatic Language Comprehension in Adult Traumatic Brain Injury:  
A Systematic Review and Meta-Analyses.**

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# PRAGMATICS AND COGNITION IN TBI: A REVIEW

## Abstract

Effective pragmatic comprehension of language is critical for successful communication and interaction, but this ability is routinely impaired following Traumatic Brain Injury (TBI) [1,2]. Individual studies have investigated the cognitive domains associated with impaired pragmatic comprehension, but there remains little understanding of the relative importance of these domains in contributing to pragmatic comprehension impairment following TBI. This paper presents a systematic meta-analytic review of the observed correlations between pragmatic comprehension and cognitive processes following TBI. Five meta-analyses were computed, which quantified the relationship between pragmatic comprehension and five key cognitive constructs (declarative memory; working memory; attention; executive functions; social cognition). Significant moderate-to-strong correlations were found between all cognitive measures and pragmatic comprehension, where declarative memory was the strongest correlate. Thus, our findings indicate that pragmatic comprehension in TBI is associated with an array of domain general cognitive processes, and as such deficits in these cognitive domains may underlie pragmatic comprehension difficulties following TBI. The clinical implications of these findings are discussed.

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In human communication, listeners are able to derive far more meaning from language than is contained in its linguistic propositions alone. Any given spoken discourse is interpreted by a listener in the context of their prior knowledge, belief, competency and values [3]. As a result the meaning of the same set of linguistic propositions can have entirely unrelated, or indeed conflictual meanings, dependent upon the context of the communication. The ability to comprehend these contextual aspects of communication is then profoundly important in enabling humans to develop effective communicative relationships with others. The ability to comprehend the implied and contextually dependent meanings within communication has been termed “pragmatics”.

Levinson [4] states: “pragmatics is the study of the relations between language and context that are basic to an account of language understanding”. To exemplify, consider the use of sarcasm in the phrase “that was such a fantastic movie!”, the use of figurative language in “I was late and so flew to work”, and the requirement for a listener to infer a request in the indirect question “are you able to close the window?”. These illustrations make clear that the meaning of an utterance can differ substantially from its content; it might mean more, less or indeed something substantially different to its linguistic proposition. This principle of linguistic underdeterminacy means that semantics alone cannot determine the proposition of a speaker when they utter a sentence. Instead, context must be drawn upon to come to an appropriate interpretation [4,5].

One view [3] is that pragmatic comprehension is itself one module of a broader system which enables us to draw inferences about the beliefs, desires and intentions of conspecifics (Theory of Mind; ToM). Wilson (p. 1132) writes:

*“Understanding an utterance involves constructing a hypothesis about the speaker's meaning [...]. Recognising a speaker's meaning amounts to recognising the intention behind the speaker's communicative behaviour, and this is a special case of the more general problem of explaining an individual's behaviour in terms of attributed mental states”.*

Clearly then, there are theoretical links between the capacity for comprehension of the implied meaning of conversational remarks and social cognition, particularly mental state reasoning.

Nonetheless, more basic cognitive processes may be more parsimoniously related to comprehension of

language implicature. Executive resources may be deployed in order to support pragmatic comprehension, for example by inhibition of inappropriate interpretations [6,7] and for general inferential reasoning [8]. In addition, due to the theoretically limitless amount of contextual information that can be drawn upon in order to inform pragmatic interpretation of any given remark [3], declarative and working memory, as well as attentional and processing resources, are likely to play some kind of supportive role in pragmatics. Indeed, neuroimaging studies have provided emerging evidence that inferential language comprehension relies on a distributed frontal-parietal network typically associated with multiple cognitive functions, including the lateral frontopolar, anterior prefrontal, dorsolateral prefrontal and anterior cingulate cortices, as well as the inferior and superior parietal cortices [9]. In short, there is a good case that pragmatics is a demanding executive ability.

### **TBI**

Traumatic brain injury (TBI) has been characterised as “alteration in brain function, or other evidence of brain pathology, caused by an external force” [10; p1637]. Neuropathological consequences of non-penetrating TBI typically include traumatic axonal injury, which is the acute functional impairment of neural axons, which can lead to cell necrosis, particularly in white matter and transcallosal tracts. In non-penetrating TBI, the frontal cortex is affected in the majority of cases, as part of a diffuse pattern of cortical lesion and degradation to the structure and integrity of axons [11-13].

TBI frequently causes disruption of communicative ability, even in the absence of core language faculty disturbances [14-16]. As such many of the communication difficulties experienced by those with TBI relate not to syntactical and lexical aspects of language but to the *pragmatics* of language comprehension and production.

In language production, persons with TBI produce shorter sentences, provide less elaboration [17], and are less time efficient in conveying information than controls [18]. They commit more errors of cohesion and coherence due to frequent derailments, interruptions and extraneous utterances [19]. They find it more difficult to plan sentences [20], and tell stories in a way that makes clear the causal

and temporal relationships between events [21]. Participants with TBI have difficulty then in the production of *meaningful* language, which requires microlinguistic aspects such as grammar and syntax to be combined with macrolinguistic skills. According to Marini and colleagues [19], macrolinguistic aspects are those processes which are “recruited in establishing cohesive and conceptual links among contiguous [...] or long-distance sentences/utterances [...] and in formulating a mental model or gist of a story or procedure” (p. 2904). Unsurprisingly then, the discourse of patients with TBI has been described as “incoherent and impoverished” [22; p282]. Partners of persons with TBI in marital dyads give similar summaries [23], and these communicative difficulties appear to remain stagnant even over the very long term [24].

In terms of pragmatic comprehension, when given novel metaphors, participants with TBI take longer to interpret their meaning, and make more errors in doing so than controls [16]. Similarly, sarcastic remarks are often misunderstood; those with TBI often accept the literal meaning of the statement or interpret it in a non-literal but nevertheless inappropriate way [25]. The ability to detect humour is also attenuated [26], and although participants with TBI perform similarly to controls without neurological injury when making basic and automatic inferences in real-world conversation, they are poorer than controls when required to employ conscious reasoning to analyse the context of a statement in order to arrive at an inference [27]. Finally, participants with TBI are less able to comprehend indirect requests than non-injured controls [28], and demonstrate an impaired ability to comprehend the “gist” of story narratives, despite intact ability to follow the microstructural aspects of a story [29].

In communicative exchanges, persons with TBI have difficulty with turn taking and topic management [30,31], more readily violate cooperation norms [32-33], and have difficulty producing communication that is appropriate to the social context [34]. That persons with TBI additionally have difficulties in recognising such norm violations when committed [34] is likely to compound the social and communicative difficulties presented by these impairments.

In addition, chronic cognitive impairments in the domains of declarative memory (encoding, storage and retrieval [35,36], working memory [37], executive functions [35,36,38,39], attention [40,41] and processing speed [42] have been documented after TBI, reflecting the diffuse nature of

TBI pathophysiology. Diffuse axonal injury in TBI is associated particularly with processing speed [43,44] and executive functioning impairments [45,46], and even mild TBI causes acute cognitive impairments [47-49] which extend to the chronic stage in a proportion of patients [50].

Finally, TBI also results in significant difficulties in social cognition. Specifically, impairments have been documented in the low level processes enabling recognition of emotion in faces and vocal prosody [38,51], as well as in the reflexive mimicry of facial emotion [52]. Higher order processes of social cognition, including the representation of the intentions and emotional state of others [53], and second order belief reasoning [54] are also impaired.

### **Need for this review**

Over a decade ago, Youse and Coelho [55] commented that despite an array of research into pragmatic communication deficits following TBI, a clear understanding of the relationship between cognition and communication disorder had not been established for this patient population. It is arguable that this remains the case. Studies have implicated a core group of cognitive processes in pragmatic comprehension; declarative and working memory, attention, executive functions and social cognition have all been investigated [9,56].

Several mechanisms have been proposed which attempt to account for difficulties in pragmatic comprehension following TBI. Schmitter-Edgecombe and Bales [57] found that following TBI, impairment in declarative memory correlated with a reduced ability to infer meaning from textual language. Working memory impairment also correlates with increasing difficulties in pragmatic comprehension [56], and as such it has been suggested that pragmatic interpretation may be compromised following TBI because these patients have poorer access to prior linguistic and contextual information during communication. Thus, persons with TBI may focus to a larger extent on individual propositions, failing to fully appreciate the integrated story and hold this information in working memory to generate appropriate inferences.

Another study investigated the involvement of social cognition in pragmatics following TBI and found that social cognition was uniquely associated with pragmatics even after accounting for the influence of general cognitive abilities, emotion perception abilities, age, injury severity and mood [58]. The authors interpret this finding as indicating that pragmatics are supported by the ability of a

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listener to infer the speaker's communicative intention, and thus that social cognition is an important cognitive aspect of impaired pragmatics following TBI.

Another study [8] bolsters claims of the importance of inference, reporting that *general* inferential reasoning abilities, but not Theory of Mind, predict pragmatic comprehension deficit in people with TBI. As such, domain general inference supported by executive processes might be of primary importance, rather than a domain specific mental state reasoning faculty (i.e. Theory of Mind).

Unfortunately the possible role of attention and speeded processing resources in TBI have been somewhat neglected in the literature. Although measures of these cognitive constructs have been correlated with pragmatic comprehension in several TBI studies with positive findings, very little attention has been directed towards interpreting these results and developing a theoretical account of the role of these ubiquitous cognitive processes within pragmatics. Nonetheless attentional impairment are common in TBI [40,42] and there are many routes by which attention impairment might conceivably lead to impaired pragmatics during real world communication. This might include difficulties in processing linguistic and paralinguistic information with sufficient speed during conversation or becoming distracted by irrelevant mental or environmental stimuli, which are common clinical observations in brain injury rehabilitation settings [59].

However, rarely has any individual study taken a comprehensive measure of all of these cognitive functions, and as a result it is difficult to draw conclusions about the *relative* importance of each in pragmatic comprehension. An estimate of this relative importance is a crucial step towards the development of a model of dysfunction in pragmatic comprehension following TBI. This will allow future research to further investigate those cognitive constructs which are not only of theoretical relevance, but also empirically implicated. There is then a need to synthesise and integrate the work done in this area.

Finally, findings from the literature in this area may not filter easily into clinical knowledge and practice, despite clear relevance to neurorehabilitative settings. The literature sits on the academic and professional boundary between Neuropsychology and Linguistics, and as a result may not be readily accessible to professionals from each discipline. However the relationship between cognition and

communication has implications clinically and may allow clinicians to understand risk factors for pragmatic difficulties based on particular cognitive impairments, and *vice versa*.

The present study attempts to address these issues by systematically drawing together published studies which report data on the cognitive correlates of pragmatic comprehension following TBI, and by quantifying the extent of each of these relationships.

### **Method**

#### **Search Strategy**

The EBSCOhost search engine was used to conduct an extensive literature search of the Medline, PsycInfo and CINAHL databases. This search was undertaken in January 2016 and yielded no systematic or meta-analytic reviews of the relationship between cognition and pragmatics .

#### **Search Terms**

Search terms were as follows:

(“ communicati\* OR conversation\* OR (language N2 comprehension) OR (expressi\* N2 language) OR (language N2 producti\*) OR (recepti\* N2 language) OR discourse OR figurative OR humo#r OR idiom OR irony OR linguistic\* OR metaphor\* OR narrative OR (persua\* N3 discourse) OR pragmatic\* OR proverb OR sarcasm OR psycholinguistic\* OR sociolinguistic\* ) AND (Amnesi\* OR attention\* OR “belief reason\*” OR cogniti\* OR “desire reason\*” OR “executive function\*” OR “executive dysfunction” OR “dysexecutive syndrome” OR “false belief” OR fMRI OR frontal OR prefrontal OR “functional magnetic resonance imaging” OR (intention N3 reason\*) OR memory OR mentali\* OR mindread\* OR neuroimag\* OR “sally-ann\*” OR “social cognition” OR “theory of mind” OR (intention N3 infer\*) OR (processing N2 speed) ) AND (“Traumatic brain injur\*” OR “head injur\*” OR “head trauma” ”)

#### **Search Limits**

These search terms were applied to article titles, abstracts and key words. Limiters were employed in EBSCOhost specifying that all peer reviewed papers published between January 1975 and December 2015 and written in the English language be returned. None of the included papers predated 1991.



### **Criteria for inclusion**

The following criteria were applied to the returned articles in order to determine eligibility.

#### *Inclusion criteria*

- i. The study includes a measure of the comprehension of pragmatics, either by:
  - a. Formal standardised measure
  - b. Novel experimental tasks
- ii. The study includes a measure of any of the following cognitive processes:
  - a. Declarative memory
  - b. Working memory
  - c. Attention / processing speed
  - d. Executive functioning
  - e. Social cognition
- iii. The study includes a defined group of participants who have sustained a TBI of at least mild severity in adulthood
- iv. The study reports correlation of the relationship between I) and II) in the TBI group

OR

- v. The authors make this data available via personal correspondence

### **Results of the Systematic Search Strategy**

Figure 1 outlines the search procedure in diagrammatic form. A total of 1,544 papers were returned using the search procedure outlined. Further investigation revealed 476 of these records were duplicates, leaving 1068 papers for screening.

In the first instance abstracts were compared against the inclusion criteria. 1009 papers were excluded at this stage, leaving 59 for full-text review. Of these, 10 papers were ultimately identified as eligible for inclusion. Appropriate correlation data was not reported in four of these papers but the authors provided this via personal communication [8,56,60,61]. The reference lists of all included papers were scrutinised for additional relevant papers. None were found using this method.

### **Data extraction**

Correlative data were extracted from the selected papers in order to populate meta-analyses. In preparation for these analyses, each pertinent correlation reported was extracted individually. Correlation coefficients were standardised by inverting where necessary, in order to ensure that a positive r-value indicated a relationship in which improvement in cognitive variable indicated an improvement of the corresponding language variable. Where multiple correlations were reported on the same construct (e.g. three different measures of executive functions were employed), these coefficients were averaged to create a single r-value for input into the appropriate meta-analysis.

### **Variable Categorization**

Neuropsychological measures employed in each study (see table 1) were categorised in the first instance by the first author with reference to an authoritative compendium of neuropsychological tests [62]. These categorisations were then reviewed by an experienced clinical neuropsychologist (author MR). Table 2 displays all measures used in the included studies and their categorisation.

### **Data Analysis**

Data extracted from the included papers was clustered according to the categorisation of variables and used to populate meta-analyses, which were computed using the “R” statistical package [63]. A total of 5 meta-analyses were performed, in which pragmatic comprehension was compared individually with each cognitive construct. Many of the ten studies reported data on more than one cognitive construct, and as such data from these papers appears in more than one meta-analysis.

## **Results**

### **Study characteristics**

Table 1 displays the characteristics of the studies included in the review. In total, the papers comprising the review included 509 participants. The average number of participants in each study was 51 and nine of ten studies reported data on participants who had sustained closed head injury (CHI). Participants were aged on average 42.8 (SD = 10.0) years of age at the time of testing, and were on average 97.8 years post injury (SD = 4.4).

### **Pragmatic Comprehension Variables**

Table 1 outlines the instruments which were taken as measures of pragmatic comprehension in the meta-analyses. Of the ten studies, six used validated measures and four used novel tasks. The measures were homogeneous in that they all assessed participant ability to make inferences about the implied meanings in ambiguous speech – whether this be related to sarcasm, humour or otherwise figurative language. Nine of the papers employed direct behavioural measures of pragmatic comprehension – requiring participants to make inferences in response to a stimulus set of ambiguous linguistic material. One study [56], employed a questionnaire measure in which clinicians rated the ability of their patients to generate accurate pragmatic inference.

### **Meta-analyses**

Table 3 displays all of the meta-analytic results and Figure 2 displays forest plots for all analyses. All cognitive variables showed significant correlations with pragmatic comprehension. Declarative memory was the strongest correlate ( $r = .605, p < .001$ ), followed by executive functions ( $r = .473, p < .001$ ) and social cognition ( $r = .421, p < .001$ ). Working memory ( $r = .320, p < .001$ ) and attention ( $r = .291, p < .001$ ) correlated less strongly.

### **Discussion**

Humans are capable of decoding the implied meanings within linguistically ambiguous speech, and do so flexibly according to the idiosyncratic context of any particular utterance. However this ability is impaired following TBI [1,2], and there was a need to systematically examine the literature with a view to identifying the extent to which this phenomenon is related to cognitive dysfunction, and which cognitive processes are most closely involved. Thus, the present paper systematically collated data from the published literature which reported correlations between neuropsychological domains and pragmatic comprehension following TBI, and used the data extracted to populate meta-analyses. We found that pragmatic comprehension correlated strongly with declarative memory, and moderate-to-strongly with executive functions. In addition, pragmatic comprehension showed moderate correlations with working memory, attention and social cognition, indicating that a broad range of domain general cognitive processes are associated with pragmatic comprehension following TBI.

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The finding that declarative memory correlates strongly with pragmatic comprehension following TBI is in accordance with theoretical accounts that describe contextual and semantic knowledge as crucial in pragmatic interpretation [3], and suggests that declarative memory processes may play a substantial role in pragmatic interpretation. However given that our review only identified three studies with modest participant numbers that spoke to this relationship, conclusions must necessarily be tentative. Nonetheless, we suggest that the impact of declarative memory impairment on pragmatic comprehension after TBI may have been overlooked in the literature, and that this area warrants further study.

A debate has arisen over recent years regarding the relative contributions of executive functions and social cognition to pragmatic comprehension [61], which has taken place in the context of a more entrenched dispute regarding the extent of independence of these cognitive constructs [64]. Our review indicates that these functions have a relationship with pragmatic comprehension which is relatively similar in strength, indicating that both may play a role in pragmatic interpretation. However the data do not offer resolute support to theoretical accounts which ascribe primacy to the role of ToM in pragmatic comprehension [3], as social cognition did not show a particularly strong correlation with pragmatic comprehension in our analyses. Additionally, given the difficulties in developing experimental tasks which precisely isolate executive components from social cognitive components in tests of the latter, many of the tasks which measured social cognition in this review contained an executive component. This issue is longstanding in the literature [65].

As such, competing theoretical positions which posit central roles for domain-specific mental state inferences (ToM) [3], versus more domain-general inferential reasoning [8] and executive inhibition [6,7], cannot be convincingly discriminated between on the basis of the current findings. At the very least it is logically clear that pragmatic interpretation requires an inference to draw conclusions based on underdetermined data; access to contextual information alone is not sufficient for understanding [5]. Whether such a task is carried out by a specialised mentalizing module or supported by a domain general executive system remains to be seen.

That working memory and attention correlated less strongly than the other cognitive constructs indicates that these may have a more peripheral role in pragmatic interpretation following TBI.

Indeed, theoretical accounts [2] have not ascribed a central role for attentional processes, but attention is nonetheless likely to have a general influence on communicative ability to the extent that lapses in attention may make pragmatic misunderstandings more likely.

Additionally, the finding that working memory correlates moderately with pragmatic interpretation provides support for the view that the two concepts are related. As suggested by Wilson [3], this role might be to hold contextual information “online” in working memory in order to draw upon it when making inferences during the interpretations of ambiguous speech. One difficulty in attempting to test this possibility using correlative designs is that working memory tasks are heavily reliant on executive resources. As such, the observed correlation between working memory and pragmatic interpretation may reflect the general importance of executive processes, rather than a specific computational role for working memory. Experimental paradigms which manipulate working memory load whilst gauging pragmatic comprehension performance would be beneficial in evaluating this putative relationship in future research.

### **Clinical and research implications**

The primary clinical finding of this review is that difficulties in pragmatics following TBI is associated with an array of cognitive impairments. Clinicians may wish to pay particular attention to the extent to which patients demonstrate pragmatic comprehension impairments during assessment when cognitive impairment is present, as it is tentatively possible to conclude that for patients with cognitive impairment following TBI, there is a risk of associated pragmatic interpretation difficulties.

Having established an empirical link between cognition and pragmatics, it becomes important to consider how impairment in pragmatics might present clinically in the context of cognitive impairment, and also to consider overlaps in the presentation of cognitive versus pragmatic comprehension impairments. One syndrome, classic after TBI, has been termed “acquired sociopathy” [66,67] and involves impaired social cognition. These typically include reduced empathy, apathy and blunted emotions, inappropriate affect, poor frustration tolerance, emotional lability, indecisiveness, poor social judgment and a tendency to act in socially inappropriate ways. Given that language is an intensely social phenomenon, and that this particular group of patients show characteristically social impairments following TBI, it might be difficult (or even undesirable) to attempt to dissociate

difficulties in pragmatics from social and behavioural disturbances. It is certainly feasible that an acquired difficulty in pragmatics might contribute to the appearance of “acquired sociopathy”; inappropriate affect could involve a misinterpretation of a speaker’s prosody, poor frustration tolerance could betray confusion in communication, and indecisiveness might relate in part to difficulties in organising verbal information into a “gist”. These links demonstrate the potentially close inter-relatedness of these clinical presentations in TBI, and the possibility that “acquired sociopathy” might be reconceptualised as arising from communication difficulty.

### **Assessment of pragmatics in TBI**

One clinical assessment tool which makes explicit this close association is The Awareness of Social Inference Test (TASIT) [68]. This assessment was developed for use in populations with TBI and assesses recognition of basic emotions as well as social inference. In the latter, videos are shown to participants depicting actors in sincere, sarcastic and deceptive exchanges. Probe questions are asked to assess whether the examinee is able to use contextual and paralinguistic cues to decode the thoughts and feelings of the speaker, as well as the message they intended to portray in their speech act (i.e. sincere, sarcastic or deceptive).

In addition, the Right Hemisphere Language Battery (RHLB) [69] is a comprehensive pragmatics assessment battery. It enables assessment of a broad range of abilities, most notably an examinee’s ability to comprehend language implicature, appreciate verbal humour, comprehend verbal and visual metaphors and decode prosody. A discourse analysis can also be completed in order to assess for any impairments in pragmatics during real social interaction with the examiner.

On the basis of the present findings then, this disorder of pragmatics appears to have neuropsychological relevance in addition to speech and language aspects for patients with TBI, and should be considered during neuropsychological assessment. Future research in this area might attempt to develop a model of the precise mechanisms by which these cognitive domains contribute to this uniquely human trait.

### **Conclusion**

The literature investigating the real-world functional use of language and its interface with cognition is beginning to provide some insights into the extent of their relationships. This review

indicates that the pragmatic interpretation of language is likely to rely substantially on a distributed, domain general cognitive architecture, and may also recruit more domain-specific social cognitive processes.

**Declaration of Interest:**

The authors report no declarations of interest.

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