

Neurocase

The Neural Basis of Cognition

ISSN: 1355-4794 (Print) 1465-3656 (Online) Journal homepage: <http://www.tandfonline.com/loi/nncs20>

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To cite this article: Cora Brown, Sarah Smith-Benjamin, Riddhi Patira & Eric L Altschuler (2016): Isolated, relative aproverbia without focal lesion, Neurocase, DOI: [10.1080/13554794.2016.1139728](https://doi.org/10.1080/13554794.2016.1139728)

To link to this article: <http://dx.doi.org/10.1080/13554794.2016.1139728>



Published online: 02 Feb 2016.



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REPORT

Isolated, relative aproverbia without focal lesion

Cora Brown^a, Sarah Smith-Benjamin^b, Riddhi Patira^c and Eric L Altschuler^{a,b}

^aDepartment of Physical Medicine and Rehabilitation, Temple University School of Medicine, Philadelphia, PA, USA; ^bTemple University School of Medicine, Philadelphia, PA, USA; ^cDepartment of Neurology, Temple University School of Medicine, Philadelphia, PA, USA

ABSTRACT

We have seen a patient with a profound, isolated, and quite selective deficit in proverb interpretation—aproverbia. The patient presented to us after an anoxic brain injury with aproverbia. Interestingly, the aproverbia appeared to be premorbid to the presenting event. Furthermore, the patient had no brain lesion that has been associated or even proposed as a cause of deficit in proverb or metaphor interpretation. The patient did have acute bilateral hippocampi lesions and associated severe anterograde amnesia, but he retained good retrograde memory with which he is able to give good, logical but concrete explanations for proverbs. This case highlights the need, importance, and interest in further neuropsychologic, imaging and functional studies of proverb and interpretation in patients and normal subjects populations.

ARTICLE HISTORY

Received 10 August 2015
Accepted 23 December 2015

KEYWORDS

Proverb; metaphor; brain injury; cognitive; memory

The interpretation of proverbs and metaphors can be used to evaluate higher-level cognitive processes in patients with differing levels of brain injuries. Yang, Fuller, Khodaparast, and Krawczyk (2010, p. 1923) note, “The ability to engage in abstract thought is to detect a higher order meaning in language and judge this meaning to be more informative than a narrow literal interpretation.” One component of the quest to unlock the human brain is to pinpoint which cortical areas allow adults to understand metaphoric language via higher-level cognitive processing. Investigators have attempted to tease out answers by comparing acquired deficits in understanding metaphoric language with brain lesion locations. Weiner and Gardener (1977) concluded that both hemispheres contributed to metaphoric competence in separate ways/modalities. Brownell, Simpson, Bihrlle, Potter, and Gardner (1990) studied the ability of patients with either left hemispheric damage (LHD) or right hemispheric damage (RHD) to interpret metaphors and found that RHD patients were drawn to the literal meaning of stimuli while LHD patients could understand and use metaphors. Yang et al (2010) attempted to pinpoint more closely where this processing occurred in the brain and concluded that impaired metaphoric comprehension in traumatic brain injury (TBI) patients arises from deficits in abstract thought as a whole. The left inferior frontal gyrus (LIFG) was a location of specific interest and was considered to be important in the selection of appropriate interpretations when contextual information is not sufficient (Yang et al., 2010). When compared to the TBI group, the control group demonstrated significantly more activity in six different brain clusters: the triangularis, opercularis of LIFG, precentral gyrus, supplementary motor areas, superior temporal pole, and left posterior middle temporal gyrus (Yang et al., 2010).

In 2013, Murphy used a proverb interpretation test (PIT) to evaluate patients with frontal lobe lesions, differentiating between the lateral and medial frontal cortex on both sides

of the brain. Patients were asked to interpret eight metaphoric proverbs and were scored from 0 to 2: Responses that interpreted the proverb in its abstract form were scored a 2, a partial abstract and correct response or a concrete yet accurate response was scored a 1, and an incorrect response, either concrete or abstract, was scored a 0 (Table 1). During the analysis of the patients’ data, Murphy found that the medial frontal cortex subgroup performed significantly worse on the PIT than all lateral cortex patients combined. From their study, they concluded that impaired performance on the PIT is associated with bilateral medial frontal lobe lesions, whereas increased concrete responses to the PIT were associated with damage to the left lateral frontal lobe (Murphy et al., 2013). From further analysis, they concluded that the anterior medial prefrontal cortex was involved in selecting the “less natural” interpretation and that the medial frontal cortex played a key role in attentional “energisation” to initiate and sustain a specific thought process or behavior (Murphy et al., 2013). With these conclusions, they proposed that concrete responses on the PIT (rather than overall performance) could represent a more sensitive measure of frontal executive function (Murphy et al., 2013).

Finally, Ianni, Cardillo, McQuire, and Chatterjee (2014) did an extensive study on metaphors. They felt that previous studies on metaphor comprehension after brain damage were not sufficiently thorough—some including only RHD patients or excluding RHD patients who performed tasks at ceiling—and that among all studies attempting to test metaphor interpretation abilities and associated brain lesion location, there was heterogeneity of the stimuli and tasks given to the patients. The goal of this new study was to create a test that could reliably evaluate metaphor comprehension in a patient while preventing false positives by testing in a way that could account for a patient’s other handicaps. They attempted to control for comprehension, visual-spatial deficits,

Table 1. Interpretation and scoring of proverb test (Murphy et al., 2013).

Score	Interpretation
0	Inaccurate concrete Inaccurate nonconcrete
1	Partially accurate and abstract Accurate concrete
2	Fully accurate and abstract

Table 2. Interpretation of metaphor test (Ianni et al., 2014).

Answer type	Explanation of answer	Interpretation of choice
Metaphor sentence		
Correct answer	The correct interpretation of the metaphor	Intact metaphor comprehension
Foil 1	Related to literal sense of the sentence	Literal bias
Foil 2	The opposite of the metaphorical sense of the sentence	Semantic integration impairment
Foil 3	Unrelated	General comprehension deficit
Literal sentence		
Answer type	Explanation of answer	Interpretation of choice
Correct answer	The correct interpretation of the literal sentence	Intact comprehension
Foil 1	Related to the agent of the sentence by category membership but not implied	Semantic selection of language that is incorrect
Foil 2	The opposite of the literal sense of the sentence	General comprehension deficit
Foil 3	Unrelated	General comprehension deficit

and the luck of yes/no answers. They used different metaphor subtypes and phrased the foil answers in systematic ways that allowed information to be gleaned from each incorrect answer regarding the patient's thought process. Three metaphor types—in nominal-entity, nominal-event, and predicate form—and targeted/defined foils (incorrect answers) were used to identify metaphor-specific deficits in different lexical regions (Table 2). The three patients presented in this study were drawn from a larger ongoing group study of metaphor comprehension.

Of the three patients studied, one patient (444DX) was found to have general sentence comprehension deficit, a second patient (384BX) had a differential metaphor deficit, as did the third patient (642KM). This patient demonstrated a selective metaphor deficit while displaying normal literal comprehension. Interestingly, patient 642KM was also not aware of his comprehension problems and felt that he "understood ninety percent of what I was reading" (Ianni et al., 2014). Patient 384BX demonstrated how the new test could decipher specific metaphor deficits. That the errors were predominantly foil 1 pointed toward literal bias in interpretation. The two patients that demonstrated disproportionate metaphor deficits (384BX and 642KM) had unilateral left hemisphere lesions. While only three patients were studied, the findings are inconsistent with the previous hypothesis emphasizing RHD in metaphor comprehension difficulties.

Case report

We describe a 40-year-old patient we were called to see 12 days after an anoxic brain injury that was secondary to an extensive medical history and hospital course. Given this history, the physical examination of the patient was surprisingly intact: The patient was pleasant, awake, alert, engaging, and comfortable. Tone was normal with full range of motion in all limbs. Cranial nerves were intact. Strength was full (5/5) in the upper limbs bilaterally and 3/5 in the lower limbs bilaterally, thought likely caused by deconditioning secondary to extensive course of recovery. Light touch and temperature sensations were intact. Muscle stretch reflexes were hyporeflexia bilaterally with an upgoing plantar reflex on the left. Cerebellar exam revealed left dysmetria on the finger-to-nose-to-finger test. The patient had appropriate affect, awake, and alert to self only. He showed poor to no short-term memory with 0/3 recall and very limited ability to remember physicians who had seen him previously or prior discussions, but good retrograde memory, for example, of his childhood and medical conditions—these as verified by discussion with family. Speech, reading, and writing were normal. The patient did not have left/right confusion or finger agnosia. The patient could solve simple—one-digit—arithmetic problems in his head and wrote down multiplication tables through 12×12 correctly. The patient solved a complex word problem (two/three-digit) involving cost of objects and change correctly without needing to use pen and paper. The patient's conversational speed and skills, expressive and receptive, were entirely normal and at a level at least as high as to be expected from his educational level—high school through eleventh grade. The patient did not have any visual deficits or hemispatial neglect.

So aside from absent short-term memory, the patient seemed mostly intact neurologically. The patient even successfully demonstrated a (simple) card trick he said he had invented and we saw some drawing and sketches he had made of symbols, e.g., for a spade, heart and diamond, and people. MRI performed one week after the anoxic brain injury was unremarkable except for bilateral symmetric restricted diffusion in the lateral aspect of the hippocampi which were hyperintense on diffusion weighted and fluid attenuation inversion recovery (FLAIR) images (Figure 1) and a large left cerebellar lesion (not shown).

In talking to the patient, there was one more particularly striking finding: literal interpretation of metaphors. When asked to interpret the phrase "the early bird catches the worm," the patient said, "when you are fishing if you want to catch something you have to start early." When asked to interpret "people in glass houses shouldn't throw stones," the patient made reference to the Flintstones cartoon. The patient gave literal explanations for proverbial phrases.

The patient was capable of abstract thought and problem solving involving both real and hypothetical situations, but his solutions were always quite concrete: When asked, "What would you do if there was a fire?" the patient stated that he would go into the bathroom because "that's where all the water is." When asked, "What would you do if you were hungry?" the patient stated he would "drink some water and check my watch to see

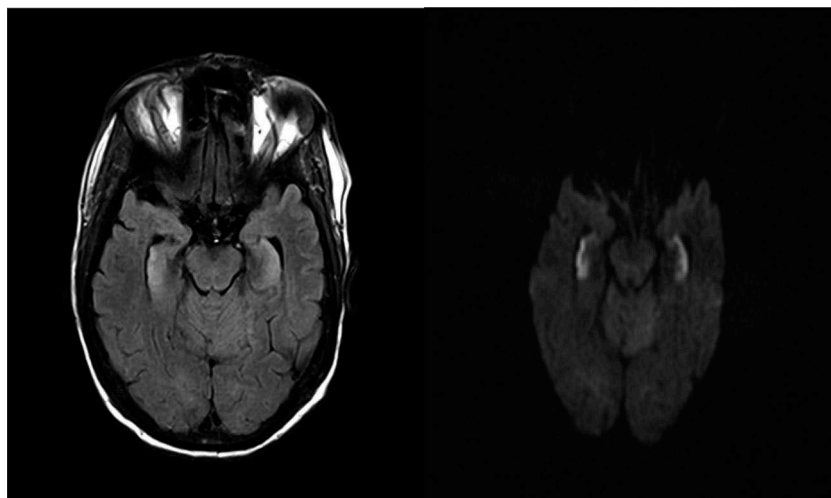


Figure 1. Diffusion weighted image (on left) showing symmetric restricted diffusion in the hippocampi and corresponding area on FLAIR (on right) with signal changes.

Table 3. Patient's response to proverb questions.

Proverb posed	Response 1	Score	Response 2	Score
Don't cry over spilt milk	Something the cat is licking	0	Milk spilt on the table	0
Rome wasn't built in a day	Napoleon was a king	0	Napoleon was a king	0
Where there's a will there's a way	Olympics, 4 circles, handicaps	1	Olympics	1
Strike while the iron is hot	Ironing clothes	0	Ironing hot	0
The grass is always greener on the other side	The sun is shining on one side	1	Summer	0
Let sleeping dogs lie	Let dogs rest	1	Rest	0
All that glitters is not gold	Art glitters	0	Or silver	0
Too many cooks spoil the broth:	The patient explained excitedly that this was a problem he saw commonly on cooking shows on TV. "Too many people running here, running there. It's a problem."	1	Spoil	0

Score 0 = inaccurate, score 1 = partially accurate abstract or accurate concrete, score 2 = accurate abstract.

when lunch would be served." This peaked our interest to further evaluate the patient's abstract cognition.

Methods

Proverbs

We tested the patient more extensively on proverbs using the set of eight proverbs studied by Murphy et al. (2013 (Table 3): We read a proverb to the patient and asked him to interpret what that sentence meant to him. We tested the set of eight proverbs twice the second time two days after the first. The patient was then graded based on the scoring criteria by Murphy et al. (Table 1).

Metaphors

We appreciated receiving a list of metaphoric and literal statements with correct answers and three foils from E. Cardillo and A. Chatterjee (personal communication) used in their study (Ianni et al., 2014). We tested the patient on 18 statements—nine metaphors and nine literals. We used three metaphor and literal statements from each of the three categories of statements in Ianni et al.: nominative entity, nominative event, and predicate statements. The task was for the patient to read the statement and select one of the four answers that best

explained the statement. The four choices consisted of the target answer and three foils (Table 2, example questions and answers in Table 5). The order of statements was randomized with regard to metaphor or literal and among the three categories. The order of answers (target, foils 1–3) was randomized for each question. Our patient's score (number of target answers chosen) was tallied and compared to the normative control data of Ianni et al. Also, our patient's score was compared to chance using a Bernoulli trial model with $p = 0.25$, $q = 0.75$ (four choices on each question with one correct answer).

Results

On the PIT, our patient scored just 25% on his first attempt and only 6.25% on his second attempt (Table 3). (When tested the second time, the patient did not remember prior testing.) The patient marked the target answer on six out of the nine metaphoric statements and six of the nine literal statements (Table 4, example questions, and answers in Table 5). He chose

Table 4. Patient's data on metaphor interpretation.

Test	Target correct	Foil profile		
		Foil 1	Foil 2	Foil 3
Literal	6 of 9	1	2	0
Metaphor	6 of 9	2	1	0

Table 5. Patient answers to metaphor interpretation test.

Statement	Type	Target answer	Foil 1	Foil 2	Foil 3	Patient's choice
The weather forecast was a flood	Literal nom-entity	High water	Newspaper horoscope	Light drizzle	Cabinet shelf	Foil 1
His lawyer's interjection was an angry yell	Literal nom-event	Fierce interruption	Joyful exclamation	Eager compliance	Quotation mark	Target answer
The cook stirred up the stew	Literal predicate	Blended ingredients	Forgetful waiter	Careful separation	Gym sauna	Target answer
Her chores were a sad tune	Metaphor nom-entity	Gloomy routine	Funeral hymn	Playful exercise	Prison system	Target answer
The letter was a polite grumble	Metaphor nom-event	Courteous complaint	Stomach gurgle	Rude rant	Wall intercom	Foil 1
Their boss pushed for more sales	Metaphor predicate	Aggressive goals	Physical force	Lenient standards	Talented actor	Target answer

two foil 1 answers and one foil 2 answer for the metaphor statements, and one foil 1 and two foil 2 choices for the literal statements (Table 4).

Discussion

We present the case of a patient with bilateral symmetric restricted diffusion in the hippocampi as a result of ischemia due to a less than week-old event—age inferred from hyperintense lesions on diffusion weighted sequence but with a hypointense apparent diffusion coefficient. The patient showed no significant neurological deficits besides anterograde amnesia (and left cerebellar lesion-associated deficits), save for a very interesting focal deficit in proverb interpretation with a much less pronounced deficit in metaphor interpretation.

In the fine-grained analysis of the proverb interpretation study done by Murphy et al. (2013), the control group performed at 66.7% ($SD = 15.6$), the right frontal-lateral brain injury group performed at 59% ($SD = 24.02$, $p = 0.154$), the left frontal-lateral brain injury group performed at 56% ($SD = 23.27$, $p = 0.195$), and the medial-frontal brain injury group performed at 48.53% ($SD = 16.76$, $p = 0.001$) (Murphy et al., 2013). The left frontal brain injury group was significantly impaired in testing, with the medial subgroup performing significantly worse than the lateral subgroups. Our patient performed at 25% and 6.25%, profoundly lower than all control and brain-injured groups.

We then compared our patient's scores to the various groups and patients from the Ianni et al. (2014) study of metaphors. The control patients performed at 96.8% accuracy in literal sentence interpretation ($SD = 1.98$) and 93.5% in metaphor interpretation ($SD = 4.65$). Foil 1 was the most commonly chosen error in metaphor condition (66.7%) as well as literal condition (78.3%, Ianni et al. 2014). Our patient performed at a lower capability than the control group regarding both metaphor and literal interpretation, which might point toward a more general comprehension deficit in this patient if solely looking at the data. However, during testing, our patient performed significantly above chance on metaphor and literal interpretation. Indeed, using a Bernoulli trial model by random chance, only 2.25 correct answers would be expected for nine questions ($SD = 1.3$) so for each of metaphors and literal statements $p < 0.05$ that the patient chose the target answer simply by choice. In aggregate for all 18

questions $p < 0.001$ that the patient correctly selected 12 out of 18 target answers simply by chance.

Looking specifically at the outcomes of the Ianni et al. (2014) test patients, patient 444DX correctly answered 86.4% of literal interpretation statements and 75% of metaphor interpretation statements. Patient 384BX correctly answered 88.1% of literal interpretation statements and 51.7% of metaphor interpretation statements. Patient 642KM correctly answered 94.9% of literal interpretation statements and 65.5% of metaphor interpretation statements. Patients 384BX and 642KM were seen as having metaphor interpretation deficits with correct scores of 51.7% and 65.5%, respectively. Our patient correctly answered a higher percentage of metaphor interpretation questions than both of these patients.

Thus, while our patient understood the utilization of posed metaphors, the patient was unable to explain the meaning of common proverbs. Murphy et al. (2013) found that fluid intelligence was not significantly different across all groups within their trial. This, combined with our patient's competencies in other mental tasks, prevents the simple conclusion that this performance is based off of some intelligence discrepancy. Our patient understood literal explanations, could perform basic mathematical problems, could read, and could abstractly answer concrete hypothetical questions, but could not supply the correct interpretation of any proverb.

We do not think the patient's profound anterograde amnesia is the cause of the aproverbia. Indeed, proverb interpretation does require contextual memory. However, intact retrograde memory is more imperative. Proverb interpretation can be seen as a procedural task—one where a nonconcrete interpretation of a sentence is utilized, and that information is put into historical context based on usage in society. The patient's multiple references to the Olympics show that this patient could in fact use retrograde memory to draw upon historical context for the proverb; however, the patient was unable to fully explain his reasoning and was instead left with just a societal association. The patient also showed intact retrograde memory and logic regarding common taught life scenarios when answering what he would do in case of a fire or if he was hungry.

Most of the literature on bilateral temporal lobe damage revolves around memory impairment, both anterograde and retrograde. When looking for examples of other patients with similar infarcts and language issues for comparison with our patient, we noticed a case study (Papagno, Capasso, & Miceli,

2009) of a 72-year-old woman with left temporal pole and medial temporal cortex hypodensities seen on voxel-based morphometry. This patient was studied due to progressive loss of her proper noun vocabulary and subsequent impairment in recalling common names and biographical information of people well known to her. In the study, the impairment in the left temporal lobe was associated with intact abstract language and capabilities, and selective abstraction preference over use of concrete nouns. The woman could not name a face shown to her, but could fluently talk about and define abstract concepts. This semantic dementia and reversed concreteness effect is thus the inverse deficit as our patient, who had difficulties with abstraction over concrete language. We have not seen a case with a similar deficit and lesion as our patient. We also did not find any cases of focal unilateral cerebellar damage causing overly concrete thinking.

Discussion with the patient's family revealed that this patient had a history of generalized deficit in concrete thinking. (The patient does not have a history of Asperger's and his engaging nature with physicians and staff goes against this being the cause of his concrete thinking.) Answers such as the ones he gave during the PIT—when read back to the family—were deemed not atypical of his thinking long before the anoxic event for which the patient presented to us. In spite of all of this, meticulous radiological interpretation of the MRI revealed no lesions in any of the seven areas implicated in metaphor interpretation (Yang et al., 2010), left or right hemisphere damage in the patients of Ianni et al. (2014), and left or right hemisphere frontal lesions in the patients with deficits in proverb interpretation of Murphy et al. (2013). There was only the newly acquired bilateral anoxic injury to the hippocampi. It appears the neurophysiologic substrate for this deficit is not clear at all, and proves to be a very captivating puzzle. However, as the MRI was done just a week after injury, it is possible that our patient has diffuse brain damage and this was present at the time of our testing, but was not yet able to be detected on MRI.

Our findings suggest a more stringent testing regimen that can be deployed at bedside for patient evaluation of brain injury and other patients. Patients are often asked to repeat phrases during a neurological examination to assess proper functioning of the comprehension-repetition pathways as well as the function and coordination of the oral muscles of speech. There are many layers to language comprehension, however. Our patient recovered from an anoxic brain injury with subtle neurological deficits that were elucidated only after directed and specific testing. There are patients who likely have “passed” all of the current more concrete neurological and cognitive evaluations who could be discharged from the hospital only to suffer after returning to work, school, or normal life where social interaction includes metaphors, proverbs, and other quirks of our modern language. These tests could be integrated by choosing one proverb and one metaphor for a patient to repeat and then interpret. It would make sense to test a patient's understanding of proverbs, then transition to metaphor comprehension testing depending on the patient's responses.

An important question concerns rehabilitation for this patient. Concrete thinking and aproverbia has been a chronic but

tolerated issue for a patient who had been able to function independently. But for many patients, cognition is considered the primary limiting factor for rehabilitation, as per evaluation by physical therapy and occupational therapy. Bronwell et al. (2013) revisited the topic researched in 1991 and devises a method for training patients in metaphor interpretation after TBI. Their method of training TBI patients to allow them to regain understanding of nonliteral language involved “graphic displays of the semantic associations that underlie metaphor” (Bronwell et al., 2013, p. 447). The patient is put through five task stages, starting with practice on evaluating connotations of single words, moving to evaluating associations of single words. Patients are then required to generate associations between two nouns, and then evaluate their own self-associations. Finally, the patients are required to choose a “shared association for two nouns that provide the basis for a metaphor” (p. 449). While enacting these tasks, graphic representations were used through “Thinking Maps”. Nouns in circles were connected via lines to associations, in smaller circles. To complete a metaphor, two nouns were required to share and connect to the same association word. On analysis, the TBI patients in this study had statistically significant improvement on the assessment of oral metaphor interpretation. Could this idea be used to also help patients with aproverbia and other deficits in higher-level thinking improve functioning?

There seem to be many more questions left asked than were there to begin with. The patient has a strikingly clear ischemic area that is acute on MRI imaging, yet the profound, selected aproverbia does not align the location of the lesion or any prior known or proposed location for the neurophysiologic substrate for proverb or metaphor interpretation, and the aproverbia appears to be premorbid to the presenting anoxic event. Metaphor and proverb interpretation has been investigated for some time now, and while there is no consensus on the cortical areas responsible for this task, our patient's lesion does not fall into any location previously implicated in proverb or metaphor interpretation. Our case suggests there might be more areas still to be explored, damage to which can cause deficits in metaphor and proverb interpretation or that such deficits can be due to nonfocal generalized abnormalities. Deficits in metaphor and proverb interpretation definitely merit further investigation from cognitive, linguistic, functional, and neurophysiologic perspectives in healthy and patient populations. As the neural basis for metaphor and proverb is still incompletely understood, all patient groups to be targeted for studied cannot yet be identified. It would be interesting to use a “mini-metaphor and proverb” exam to test patients routinely.

Acknowledgments

We thank E. Cardillo and A. Chatterjee for helpful discussions and for giving us their metaphor statements and answers and foils. We thank V. S. Ramachandran for helpful discussions.

Disclosure statement

We have no financial or other conflicts.

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