J Autism Dev Disord (2015) 45:3606–3612
DOI 10.1007/s10803-015-2508-4

ORIGINAL PAPER

Strange Words: Autistic Traits and the Processing of Non-Literal Language

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Published online: 21 June 2015

Abstract Previous investigations into metonymy comprehension in ASD have confounded metonymy with anaphora, and outcome with process. Here we show how these confounds may be avoided, using data from non-diagnosed participants classified using Autism Quotient. Participants read sentences containing target words with novel or established metonymic senses (e.g., *Finland*, *Vietnam*) in literal- or figurative-supporting contexts. Participants took longer to read target words in figurative contexts, especially where the metonymic sense was novel. Importantly, participants with higher AQs took longer still to read novel metonyms. This suggests a focus for further exploration, in terms of potential differences between individuals diagnosed with ASD and their neurotypical counterparts, and more generally in terms of the processes by which comprehension is achieved.

Keywords Autistic traits · Autistic Quotient · Figurative language · Language processing

Metonymy refers to the figurative use of one concept to instantiate something broader, such as the use of *Dickens* to refer to books authored by Charles Dickens, rather than to the author himself. Metonyms are interesting because they appear frequently in natural discourse, but are not 'flagged' as figurative (Papafragou 1996). In line with other forms of figurative language, there is evidence to suggest that metonyms cause difficulty for those with Autism Spectrum Disorders (ASD). For example, MacKay and Shaw (2004) found that children with autism were less able to adequately explain the underlying meanings of metonyms than were children matched on verbal IQ; and in a study inspired by Happé (1994), Rundblad and Annaz (2010) found that children with ASD diagnoses were less able to provide appropriate interpretations of metonymic vignettes (see also Zheng et al. 2015). However, in contrast to other types of figurative language, such as metaphor, the understanding of metonymy improves with chronological age in both neurotypical (NT) and ASD populations (Rundblad and Annaz 2010), and does not correlate with performance on the Children's Embedded Figures Test (Witkin et al. 1971), which measures the ability to perceive embedded parts of an organised visual field. Evidence concerning the comprehension of metonymy may therefore help to distinguish between accounts which explain figurative language comprehension deficits in terms of weak central coherence (Frith 1989) and others (see also Melogno et al. 2012).

However, current evidence concerning metonymy comprehension remains open to interpretation. Previous work has confounded metonymy and anaphora; and the focus of investigation has been on the *outcome* of the comprehension processes (the interpretation reached), rather than on the *processes* of comprehension. These processes may, themselves, vary across populations. Here, we present a pilot study which investigates the ways in which 'pure' unconfounded metonyms are processed. Our evidence comes from non-diagnosed participants differentiated in terms of Autism Quotient (AQ: Baron-Cohen et al. 2001): Although our findings may have implications for figurative language comprehension in ASD, our primary aim is to demonstrate the utility of tasks focusing on on-

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line linguistic processing in providing a complete account of the understanding of non-literal language across populations.

In studies investigating metonymy comprehension in ASD, the targets for comprehension tend to be used not only figuratively, but *anaphorically*: For example, Rundblad and Annaz (2010) used *Robbie Williams* (a famous British singer-songwriter) to refer to a CD (producer-for-product metonymy) in a context where the CD had previously been mentioned (anaphoric reference to an explicit antecedent). This usage is consistent with Song's (1998) conceptualisation of metonymy as ad-hoc labelling of previously mentioned entities, but misses the more general definition of metonymy as any non-literal mapping from source (e.g., *Robbie Williams*) to target (e.g., items that Robbie Williams has produced: Barcelona 2003). Importantly, in this broader sense, no antecedent is required for successful interpretation. The question *Do you like Robbie Williams*? can be understood, as can *Do you like Dickens*? without any previous mention of CDs or books. Existing research therefore leaves open the question of whether the primary deficit exposed is one of understanding that, figuratively, *Robbie Williams* can be used to refer to a CD, or one of linking the present mention of *Robbie Williams* to a particular, previously mentioned, CD. Since people with ASD have documented difficulties in establishing textual coherence (e.g., Baltaxe 1977; see also de Villiers et al. 2014, for a review of language comprehension in Asperger Syndrome), it may be that the deficits previously reported for metonym comprehension are, in fact, confounded with deficits in the comprehension of anaphora.

One reason that previous research has used explicit anaphoric antecedents in metonymy tasks is that the focus of evaluation has been whether metonyms are successfully comprehended. Participants are asked questions to determine whether they have understood that *Robbie Williams* refers to the previously mentioned *CDs*. This type of experiment is typical of research into ASD, in which the outcomes of cognitive processes are often the focus of investigation. Different outcomes have been reported, for example, in producing successful imitations (Williams et al. 2004; Rogers and Williams 2006), understanding others' beliefs and intentions (Baron-Cohen et al. 1985; Baron-Cohen 1987), and in the understanding of contextually licensed nonliteral language (Happé 1994). However, in many cases, people with ASD achieve similar test scores to their NT peers (for example, on tests of Theory of Mind, Happé 1995). Although the possibility that these "talented" individuals use strategies (or, more generally, use different processes) to achieve typical performance has long been discussed (e.g., Happé 1993, 1995), the extension of this suggestion—that people with ASD may more generally achieve typical outcomes using atypical processes—remains under-explored. It remains possible, for example, that some types of figurative language are understood as well by people with ASD as they are by their peers, but that the outcome in question (i.e. successful interpretation) is achieved in different ways. Any such differences in processing may be particularly relevant in cases like metonymy where a literal (*Robbie Williams* the person) and a figurative (*Robbie Williams* the CDs) interpretation are in competition.

A general proposal for the processing of figurative language across populations is that the literal meaning is initially accessed, regardless of other factors (e.g., Grice 1975, 1978). On this *literal-first* view, an alternative figurative 'layer' of meaning is only added when the literal meaning turns out to be inappropriate (an alternative, figurative-first, view has also been proposed: e.g., Gibbs 1994). On the assumption that changing an interpretation takes time, a listener may take longer to process *Daniel Johnston* where the intended referent is a CD than when the singer is intended. In the case of *Robbie Williams*, however, the name may frequently be used in common parlance to refer to the music, rather than to the person. Frequent metonymies such as this may simply be learnt, as a form of polysemy. In such cases, the intended figurative sense may be readily available to the comprehender, and there may be little evidence of a cost associated with switching interpretations.

Taking the literal-first hypothesis as a starting point, Frisson and Pickering (1999, 2007) investigated the comprehension of metonymy in the neurotypical population. A series of experiments examined the comprehension of place-for-institution (*the minister had an argument with the embassy*: Frisson and Pickering 1999, Experiment 1) and place-for-event metonymies (Experiment 2, see (1) below), as well as producer-for-product metonyms (Frisson and Pickering 2007). Frisson and Pickering (1999, Experiment 2) measured participants' eye movements as they read sentences like those in (1), in which the literal (a, c) or figurative (b, d) interpretations of targets such as *Vietnam* or *Finland* were supported by the material preceding the targets in sentential contexts.

1. a. During my trip, I hitchhiked around Vietnam, but in the end I decided to rent a car…
   b. A lot of Americans protested during Vietnam, but in the end this did not alter…
   c. During my trip, I hitchhiked around Finland, but in the end I decided to rent a car…
   d. A lot of Americans protested during Finland, but in the end this did not alter…

Participants were not slowed down at *Vietnam* in (1b) relative to (1a), in line with the suggestion above that, for metonyms which are commonly used, a figurative interpretation is likely to be readily accessible. However, in (1d), a metonymic interpretation of *Finland* must be derived on-the-fly based on the immediate linguistic context in which the word is encountered. In this case, participants were slowed down relative to (1c), suggesting that there is a measurable cost associated with deriving a metonymic meaning where it is not already known. Similar patterns of results were found for *embassy* versus *cottage* (1999, Experiment 1: see 2, below, for example materials); and for *Dickens* versus *Needham* as producer-for-product metonyms, similar to *Robbie Williams* in the examples discussed earlier (Frisson and Pickering 2007).

Frisson and Pickering's experiments allow us to directly observe the time-course of the comprehension of figurative meaning. The cost associated with (1d) relative to (1c) is not confounded by processes involved in the identification of anaphoric antecedents, because the metonyms in (1) do not refer back to previously established referents; moreover, because the cost is expressed as a reading time (rather than being assessed in terms of whether the interpretation was 'correct') it is likely to be sensitive to relatively small differences between people. For this reason, we have elected to demonstrate the usefulness of a reading-time approach by replicating Frisson and Pickering's study using participants from the general population, who are differentiated in terms of Autism Quotient (AQ). The AQ is 50 item self-report measure designed to assess ASD traits in typically developing adults of normal intelligence (Baron-Cohen et al. 2001). The items assess five principle dimensions of ASD: Social Skills, Attention Switching, Attention to Details, Imagination, and Communication. The AQ is one of a handful of broader autism phenotype (BAP) metrics that purport to measure subclinical ASD traits within the typical population. Although AQ is not diagnostic of ASD, an AQ-related difference in metonymy processing would be nevertheless be of interest, given the uncertainty about previously reported findings concerning metonymy processing in ASD.

Given previous findings from the ASD population, we might expect people with higher AQs to show relative difficulty in understanding figurative language. Based on Frisson and Pickering's (1999) evidence from the neurotypical population, we would expect any such difficulty to be particularly associated with novel metonymies. In other words, we would expect participants to take longer to read *Finland* in (1d) compared to (1c), because the intended metonymic meaning must be inferred during reading; and we would expect this difference to be emphasised for participants with higher AQs.

We note that using reading time measures, relative difficulty can be demonstrated *whether or not the intended meaning is successfully comprehended in all cases*. For simplicity of implementation and for ease of interpretation, our experiment is implemented using self-paced-reading (Mitchell and Green 1978), an experimental technique which correlates well with eyetracking (Just et al. 1982; Witzel et al. 2012).

Method

Participants

Sixty-eight participants (43 female, to ensure that lower as well as higher AQ scores were likely) volunteered to take part in the study. Participants were university students whose ages ranged from 17 to 24, recruited from a variety of disciplines (ranging from Engineering to Psychology) at Heriot-Watt University, Edinburgh. Participants were awarded course credit in exchange for participation where feasible. All participants had English as a first language, and none reported relevant language-related difficulties. Participants provided written consent prior to testing.

Design

The experiment had a 2 × 2 × 2 mixed design with the within-participants factors of *Context* (literal-supporting vs. metonym-supporting) and *Familiarity* of metonymic meaning (familiar vs. non-familiar). The between-participant factor was *Autism Quotient* category (High vs. Low, based on a median split of AQ scores obtained). The reading region of interest was the critical noun (i.e. the segment of text including the metonym).

Materials

Autism Spectrum Quotient

The Autism Spectrum Quotient (AQ: Baron-Cohen et al. 2001) is a 50-item self-report questionnaire designed to measure autistic traits. Each item is said to reflect features of the condition's clinical profile (e.g., 'I notice patterns in things all the time'). Responses are made using a 4-point Likert scale ranging from "definitely agree" to "definitely disagree". Items are counterbalanced such that for half, a positive response indicates an autistic-like trait, whereas for the other half, a negative response is indicative. Each response consistent with an autistic-like trait is given a score of 1, resulting in a maximum score of 50. Studies to date suggest that individuals diagnosed with autism tend to score $\geq$32, whereas individuals without autism on average score around 16; however, the test is not diagnostic, and care should be taken with its interpretation.

Metonymy Items

Materials for the reading task were adapted from Experiments 1 and 2 of Frisson and Pickering (1999). We selected 16 sets of 4 sentences similar to (2), from Experiment 1, and 16 like (1) from Experiment 2. The principal criterion for selection was that the familiar metonymic senses used (e.g., in 1b, 2b) would still be familiar to participants, over a decade after the materials were created.

2. a. Those angry protesters surrounded/the embassy/, but not much/was achieved/by it.
   b. The minister had an argument with/the embassy/, but not much/more could be/done.
   c. Those angry protesters surrounded/the cottage/, but not much/was achieved/by it.
   d. The minister had an argument with/the cottage/, but not much/more could be/done.

Each of the 32 sets of sentences comprised one of two contexts combined with one of two target nouns. *Contexts* were manipulated such that the material before the target noun favoured either a literal or a metonymic interpretation of the target (e.g., 2a, c vs. 2b, d), but the few words following the target were always identical. In literal contexts, the target had a sense that was either a location (1a, c) or an edifice (2a, c); in metonymic contexts, either an event (1b, d) or an institution (2b, d) was intended. The *Familiarity* of the metonymic interpretation of the target was manipulated such that the target was either frequently used in a metonymic sense (as in 1a, b and 2a, b) or was a length-and-frequency matched control that was seldom used in a metonymic sense (as in 1c, d and 2c, d: see Frisson and Pickering 1999, for evidence concerning the frequencies of metonymic senses extracted from the British National Corpus, as well as other pretests). Items were segmented into 5–8 phrases for phrase-by-phrase display in a self-paced reading task. The target always occurred as either the 3rd or 4th phrase displayed. We created 4 lists from the 32 sets of items, such that each list included equal numbers of sentences representing each item condition, and no two sentences from the same item occurred in any list.

Procedure

Participants began by filling out a pen-and-paper version of the AQ. Upon completion of the AQ the experimenter introduced the computer-based cumulative phrase-by-phrase self-paced reading task. The task was administered using a laptop, with participants seated at a comfortable viewing distance from the screen. Participants first read through deliberately verbose instructions, designed to encourage a natural reading speed. Following this, a press of the spacebar started the presentation of the first practise item, which was a neutral sentence. Pressing the spacebar revealed the first 2–3 word phrase of the sentence, centred vertically on the laptop screen and aligned with the left margin. A subsequent press of the spacebar extended the displayed phrase to the right by adding the next 2–3 words. To complete the reading of each sentence, the participant continued to press the space bar, revealing 2–3 word phrases, until the end of the sentence (indicated with a full stop) appeared. The next press of the spacebar revealed a prompt to press the spacebar for the second practise item. After the second practise item, the 32 experimental items were shown, in an order randomised per participant. No constraints were placed on the randomisation. The procedure for each item was identical to that for the practise items, with the exception that eight (25 %) of the experimental items were followed by simple statements which were true or false with respect to some aspect the sentence just read (for example, *there were a lot of protesters in Vietnam*). Half of the statements were true. Participants indicated whether each statement was true, using either the "Y" or "N" keys, before proceeding to the next item. The times between each press of the spacebar were recorded (in milliseconds); of primary interest was the time to read the target word, measured between the keypress which revealed the relevant word, and that which revealed the next few words of the item.

Results

Autism Quotient

Across the 68 participants, AQ ranged from 2 to 35, with a mean of 14.3 (SD 6.4) and a median of 13.5. Participants were split at the median into two equal-sized groups, referred to here as Low AQ and High AQ, for further analysis. Characteristics of the groups are given in Table 1.

Response Accuracy

Response accuracy for the comprehension questions was 100 % for all participants.

Table 1 Characteristics of the high and low AQ groups

	Mean AQ (SD)	Mean Age Y; M (SD)	Gender
High AQ	19.2 (5.2)	20;11 (0;6)	22F/12M
Low AQ	9.4 (2.6)	21;2 (1;10)	21F/13M

Table 2 By-participant mean reading times in milliseconds for target regions, for the whole study and by AQ group

	Familiar metonym		Unfamiliar metonym	
	Literal context	Metonymic context	Literal context	Metonymic context
Whole study	691 (200)	735 (240)	652 (182)	779 (248)
Low AQ	693 (230)	744 (283)	659 (213)	726 (204)
High AQ	689 (169)	725 (192)	644 (147)	832 (279)

Standard deviations are in parentheses

Reading Times

Prior to analysis, three observations were removed, as the recorded target reading times exceeded 8 s in each case (0.1 % of the data). Target reading times were determined by visual inspection to be normally distributed.[1] Mean target reading times, for the whole study and for the Low and High AQ participant groups, are given in Table 2.

Our analysis of the experiment included the two within-participants factors of Context (literal or metonymic) and Familiarity of metonymic meaning (familiar or unfamiliar), together with the between-participants factor of AQ group (low or high AQ). Participants were slowed down by 86 ms when interpreting targets in a metonymic context [$F(1,66) = 24.8$, $p < .001$, $\eta_p^2 = .27$]. Consistent with earlier research, there was however an interaction of context with the familiarity of the metonymic sense [$F(1,66) = 6.33$, $p = 0.014$, $\eta_p^2 = .09$] such that the difference was much smaller when the metonym was familiar (44 ms) than when it was novel (127 ms). Importantly for the present research, the interaction between context and familiarity itself interacted with AQ group [$F(1,66) = 4.14$, $p = 0.046$, $\eta_p^2 = .06$]. Participants with Low AQ were slower to interpret metonyms than literal meanings, but the additional cost of interpreting an unfamiliar metonym was only 16 ms; for participants with high AQ, the equivalent figure was 151 ms. Other than those reported here, no other effects were significant.

In an additional analysis we examined the effects of Context and Familiarity separately for each of the low and high AQ groups. For the low AQ group, there was a main effect of Context [$F(1,33) = 8.3$, $p = .007$, $\eta_p^2 = .20$] such that participants were 59 ms slower to interpret metonymic meanings; no other effects were significant. For the high AQ group, there was a main effect of context [$F(1,33) = 16.6$, $p < .001$, $\eta_p^2 = .33$], representing a difference of 112 ms. Critically, there was also an interaction between Context and Familiarity [$F(1,33) = 10.8$, $p = .002$, $\eta_p^2 = .25$] such that participants in the high AQ group were slowed down by 36 ms by familiar metonyms but by 188 ms when they were caused to generate a novel metonymic interpretation.

[1] A set of additional analyses in which outliers over 2.5 SD from participant-specific means were removed resulted in identical patterns of significance.

Discussion

When participants encounter a word such as *Finland*, they are slower to read in its figurative sense as an event, signalled by the word *during* which immediately precedes it, than in its literal sense as a country east of Sweden. However the figurative disadvantage is much smaller when the metonymic sense has been established in common usage, such as when *Vietnam* is used to refer to the conflict of the 1950–1970s, rather than to the country east of Cambodia. These findings replicate eyetracking experiments reported by Frisson and Pickering (1999). The present study additionally shows that this ‘unfamiliar metonym disadvantage’ is driven by participants with high AQ: In other words, participants with greater numbers of self-reported autistic traits are relatively slowed down by *Finland*; participants with low AQs are not.

In contrast to previous investigations of metonym comprehension, the present study does not employ metonyms which explicitly refer to previously mentioned referents (such as *Robbie Williams* referring to a previously mentioned *CD*; Rundblad and Annaz 2010). This suggests that difficulties previously observed in metonym comprehension cannot be wholly attributed to difficulty in establishing textual coherence. Instead, the differences in processing between participants with high and with low AQs must be associated with the non-literal mapping of a source (*Finland*) to a previously-unmentioned target (event; Barcelona 2003). Thus it would appear to be the process of interpretation which differs between our participant groups.

Note however that there is no evidence that any participants *failed to understand* the sentences they were reading (responses to the comprehension questions were at ceiling, although we should note that these questions did not probe the specific figurative or literal meanings of the target nouns). Instead, the observable differences between groups implicate *processing* directly; either people with high AQs took longer to engage the same processes, or there is evidence that the stimuli were processed differently across groups. On the literal-first hypothesis, for example, it may be the case that participants with high AQs entertain (and attempt to integrate) literal interpretations of unfamiliar metonymic nouns for longer than their low AQ counterparts. This may lead to a processing *bias*, observable using online measures; there is no a priori reason to assume that it would lead to a processing *failure* (and indeed, the processing failures documented by Rundblad and Annaz might be attributable to failures in anaphoric resolution rather than metonymic interpretation). This processing bias arguably suggests there is a cognitive style difference that relates to speed of information processing rather than something that could be attributed to an inability to process nonliteral language in context (weak central coherence). Whether this difference extends from subclinical to a clinical population is a future research question.

The general implication of studies such as this is that, by focusing on the outcomes of cognitive processes, we may miss evidence which can lead to a detailed understanding of the ways in which cognition can differ between groups. By focusing on the processing anterior to a response, a different picture may emerge. For example, Senju et al. (2010) were able to show that, despite question-answering performance that was equivalent between groups once verbal mental age was taken into account, children with an ASD diagnosis were less competent in correctly fixating the intended location in a false belief task. As for our (adult, non-diagnosed) participants, there appears to be a difference between task competence and task execution. Pursuing this line of reasoning further suggests that it is not only those activities for which 'deficits' in outcome are evident that may make useful arenas of enquiry when attempting to characterise cognitive differences between groups. Examining any complex cognitive activity as it unfolds may illustrate differences in processing (e.g., dynamic scene viewing: Klin et al. 2002, 2003); language comprehension is particularly open to investigation using the techniques of psycholinguistics, such as self-paced reading and eyetracking.

The present study is suggestive of a processing difference between those with self-identified autistic traits and those without. There is no evidence that the *outcome* differs between groups, but there is a suggestion that the comprehension of figurative language is a skill which causes more difficulty for people with high AQ, and perhaps, by extension, for those with ASD diagnoses.

Acknowledgments The authors would like to thank Bill Woodside, University of Strathclyde, for help in implementing the experiment.

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