University of Richmond
UR Scholarship Repository

Honors Theses | Student Research

2024

Examining the Link between Autistic Personality Traits and Processing of Metonymy

Miranda Moe

Follow this and additional works at: https://scholarship.richmond.edu/honors-theses

 Part of the Psychology Commons

Recommended Citation

Moe, Miranda, "Examining the Link between Autistic Personality Traits and Processing of Metonymy" (2024). *Honors Theses*. 1780.
https://scholarship.richmond.edu/honors-theses/1780

This Thesis is brought to you for free and open access by the Student Research at UR Scholarship Repository. It has been accepted for inclusion in Honors Theses by an authorized administrator of UR Scholarship Repository. For more information, please contact scholarshiprepository@richmond.edu.

Examining the Link between Autistic Personality Traits and Processing of Metonymy

by

Miranda Moe

Honors Thesis

Submitted to:

Department of Psychology
University of Richmond
Richmond, VA

May 3, 2024

Advisor: Dr. Matthew Lowder

Abstract

Previous research has investigated the real-time processing and offline interpretation of metonyms. This work has generally shown that readers experience longer processing times for metonyms versus control nouns because of the extra time needed to access the figurative sense of a metonym. Recent research has also demonstrated different processing patterns on nonliteral language for individuals with autism spectrum disorder compared to typically developing participants. The current study was designed to explore whether previous findings on the processing of metonymy are modulated by individual differences in autistic personality traits. Through an eye-tracking during reading experiment, participants read sentences in which factors of sentence structure (ambiguous vs unambiguous) and subject noun type (metonym vs inanimate controls) were manipulated. Participants also completed the Autism Spectrum Quotient (AQ). Results replicated previous findings in showing that readers have a bias to access the figurative sense of a metonym when it appears as the subject of a sentence; however, this effect was only found for participants who scored lower on the AQ. Instead, participants who scored higher on the AQ showed equivalent processing patterns for sentences, regardless of whether the subject was a metonym or an inanimate control. These results show that individual differences in personality traits have the potential to explain variability in sentence processing.

Communication in everyday language is more complex than simply accessing the literal meanings of words and combining those words into sentences. Communication also relies heavily on non-literal language such as metaphors, idioms, and metonymy, where meaning goes beyond the literal definitions of individual words. Additionally, contextual and non-verbal cues like prosody and gestures provide essential information for deriving a complete understanding of language. Thus, an awareness of non-literal language is necessary for fully grasping the intended meaning in everyday discourse, which involves much more than basic vocabulary and grammar (Hauptman et al.,2023).

One of the most common types of non-literal language is metonymy. Metonymy is a type of figurative expression in which one entity or event is used to refer to another, related, entity or event. Metonyms often operate in both figurative and literal senses. For instance, “The White House” literally refers to a physical building, but metonymically represents the U.S. government. The corresponding metonymic term is “Number 10” in the UK and “The Blue House” in South Korea (Littlemore, 2017). All these examples are referred to as place-for-institution metonyms. And, there are many others. Some types of metonyms are illustrated below (Frisson & Pickering, 1999).

- I am reading Shakespeare.
- The BLT is a lousy tipper.
- A lot of Americans protested during Vietnam.
- Hussein invaded Iraq.

One major debate in psycholinguistics is whether literal and nonliteral expressions are processed differently or follow similar comprehension mechanisms. Research into the processing of metonymy has illuminated ways different types of metonymy are processed in familiar and unfamiliar contexts. In two eye-tracking experiments by Frisson and Pickering,

the authors explored the processing cost of metonyms compared to literal expressions. In the first experiment, they investigated the processing of familiar and unfamiliar metonyms that could appear in literal versus figurative sentence contexts, as in (1).

1a. The photographer stepped inside the college after he had received an official invitation (Literal Context-Familiar Metonym).

1b. The photographer stepped inside the pyramid after he had received an official invitation (Literal Context-Unfamiliar Metonym).

1c. The bright boy was rejected by the college after he had bribed some crooked officials (Figurative Context-Familiar Metonym).

1d. The bright boy was rejected by the pyramid after he had bribed some crooked officials (Figurative Context-Unfamiliar Metonym).

The findings from the first experiment indicated that participants experienced the greatest processing difficulty, as evidenced by longer reading times in early and late eye-tracking measures, when encountering sentences like (1d), while other conditions either did not differ from each other or differed to a smaller degree. Based on this pattern, the authors suggested a version of a parallel processing model such that readers are able to access both figurative and literal senses simultaneously if the metonym is familiar. The authors found a similar pattern of results in their second experiment using place-for-event metonyms. Importantly, however, there was evidence for longer reading times and more regressions for familiar metonyms in sentences like (1c) compared to (1a). Because the processing cost was greater for unfamiliar metonyms compared to familiar metonyms, Frisson and Pickering claimed that their data provided weak evidence for the indirect access model.

Despite their important contribution to the literature on metonym processing, the items in Frisson and Pickering appeared in a variety of sentence structures. For example,

some of their target words appeared as the object of a verb, whereas others appeared as part of an adjunct phrase. Based on this observation, Lowder and Gordon (2013) conducted a follow-up experiment in which they carefully controlled the syntactic structure of all items. In Experiment 1, participants read sentences containing place-for-institution metonyms, where the target metonym appeared as the verb's object, as in (2).

2a. The journalist photographed the college after he had received an official invitation (literal-familiar)

2b. The journalist photographed the pyramid after he had received an official invitation. (literal-unfamiliar)

2c. The journalist offended the college after he had received an official invitation. (metonym-familiar)

2d. The journalist offended the pyramid after he had received an official invitation. (metonym-unfamiliar)

Unlike Frisson and Pickering (1999), Experiment 1 of Lowder and Gordon (2013) indicated that metonyms in both conditions caused processing difficulties compared to when the words were used literally; however, the difficulty in the unfamiliar condition was more prolonged. Additionally, the authors found that the metonymic-unfamiliar condition (e.g., offended the pyramid) was more difficult than the metonymic-familiar condition (e.g., offended the college) in later measures of eye-tracking. Therefore, these results from Experiment 1 are consistent with the indirect-access model of figurative language processing, such that the literal meaning is computed before the figurative meaning.

Lowder and Gordon's (2013) Experiment 2 examined whether the processing difficulty observed for familiar metonyms in Experiment 1 would be reduced when they appeared as part of an adjunct phrase (e.g., "offended the honor of the college") compared to

when they appeared as an argument of the verb. Additionally, Experiment 2 tested whether interpreting familiar metonyms imposed a processing cost compared to a different baseline. While metonymic expressions like "offended the college" indirectly refer to people (e.g., the administration), they can be substituted with a noun phrase that directly refers to a person or group (e.g., "offended the leader"). This comparison offered another test of models of figurative language processing, contrasting the predictions of the indirect-access model (which suggests readers will encounter difficulty with metonymic expressions compared to literal expressions) and the direct-access model (which predicts no difference). The results replicated the results of the first experiment in demonstrating that metonyms are harder to process than literal expressions when the target word is the object of the verb. Importantly, the results also indicated that when the noun phrase appeared as part of an adjunct phrase (e.g., “the honor of the college”), the processing difference between the metonyms and people condition was reduced or eliminated—a finding that is consistent with the predictions of the direct-access model of figurative language processing.

While the previous studies embedded target words in a sentence context, Fishbein and Harris (2014, Experiment 1) investigated which sense would be accessed first when metonyms appeared as subjects of the sentence without a prior context. In self-paced reading and eye-tracking studies, the authors used producer-for-product metonyms as sentence subjects. The verb phrase following the metonym indicated whether the metonym should be understood in its literal person sense (3a) or its figurative product sense (3b).

3a. As planned, Kafka was contacted by the publisher shortly after the revisions were in.

3b. As planned, Kafka was printed by the publisher shortly after the revisions were in.

The results suggested that readers showed greater difficulty processing the verb region and by-phrase in (3b) than in (3a). The authors interpreted this result as supporting the Subject-as-Agent Principle, according to which readers tend to assign an agent thematic role to sentence subjects when such an interpretation is possible. In the case of a producer-for-product metonym like Kafka, assigning an agent role to the metonym entails activating the literal sense of the metonym. Fishbein and Harris proposed that this account is consistent with the "Underspecification Model," where readers might initially activate all senses of a word available to them, but later hone in on the relevant sense.

To further explore the subject-as-agent principle, Lowder et al. (2023a) used place-for-institution metonyms (e.g., "hospital") as sentence subjects. In the case of place-for-institution metonyms, the literal sense is inanimate while the figurative sense is animate. By positioning these words in syntactically ambiguous versus unambiguous sentences, the authors were able to assess the extent to which readers initially accessed a figurative sense of the metonym such that it could serve as the agent of the verb—an interpretation that is rendered incorrect at the disambiguating by-phrase.

4a. The hospital requested by the doctor was not entirely ready for a full staff to begin working. (Metonym-Ambiguous)

4b. The hospital that was requested by the doctor was not entirely ready for a full staff to begin working. (Metonym - Unambiguous)

4c. The equipment requested by the doctor was not entirely ready for a full staff to begin working. (Inanimate - Ambiguous)

4d. The equipment that was requested by the doctor was not entirely ready for a full staff to begin working. (Inanimate - Unambiguous)

Analysis of several reading-times measures showed a main effect of sentence structure, with longer reading times observed for ambiguous sentences compared to unambiguous sentences. In addition, analysis of regression-path duration indicated longer reading times for the metonym condition versus the inanimate condition, but only within ambiguous sentences, such as sentence (4a). This implies that participants were more likely to be garden-pathed in ambiguous sentences and that the magnitude of that effect was larger for metonyms than inanimate control nouns. The results suggest that readers had a bias to interpret metonyms in subject position as agents, which resulted in a processing cost later in the sentence when that interpretation is no longer possible.

Experiment 2 aimed to compare the processing of place-for-institution metonyms to animate control nouns, investigating whether animate nouns referring to people would yield larger garden-path effects than metonyms due to their ability to serve as agents in the literal sense, or if comprehenders' tendency to assign the agent role to sentence subjects whenever possible would result in similar garden-path effects for both metonyms and animate controls. The authors examined the processing differences between place-for-institution metonyms and animate nouns, as in (5).

5a. The hospital requested by the doctor was not entirely ready for a full staff to begin working. (Metonym, Ambiguous)

5b. The hospital that was requested by the doctor was not entirely ready for a full staff to begin working. (Metonym, Unambiguous)

5c. The specialist requested by the doctor was not entirely ready for a full staff to begin working. (Animate, Ambiguous)

5d. The specialist that was requested by the doctor was not entirely ready for a full staff to begin working. (Animate, Unambiguous)

The magnitude of garden-path effects in the metonym condition was identical to the magnitude of garden-path effects when the subject was an animate noun, suggesting that metonyms in subject position are processed as agents, just as if they were animate nouns. The lack of difference in the magnitude of garden-path effects in the two conditions provides strong evidence that readers selected the figurative sense of the metonym so that it could serve as the agent of the verb.

The results of Lowder et al. (2023a) raise the question whether there are immediate processing differences on the noun itself for metonyms vs inanimate nouns. Accordingly, Lowder et al. (2023b) measured eye movements while participants reach sentences like those in (6), which were identical to sentences like in (4) but with an introductory clause. Importantly, the metonyms and inanimate nouns were matched on average for length, frequency, orthographic neighborhood size, and concreteness.

6a. As usual, the hospital requested by the doctor was not entirely ready for a full staff to begin working. (Metonym, Ambiguous)

6b. As usual, the hospital that was requested by the doctor was not entirely ready for a full staff to begin working. (Metonym, Unambiguous)

6c. As usual, the equipment requested by the doctor was not entirely ready for a full staff to begin working. (Inanimate, Ambiguous)

6d. As usual, the equipment that was requested by the doctor was not entirely ready for a full staff to begin working. (Inanimate, Unambiguous)

The results replicated the previous study, indicating that readers have a bias to initially adopt the figurative sense of place-for-institution metonyms when they appear as subjects. This bias is evident from the larger garden-path effects observed for metonyms compared to inanimate nouns. Furthermore, the analysis of gaze duration and regression-path duration on

the subject noun phrase revealed longer reading times for metonyms than inanimate nouns. These reading times suggest a processing cost associated with readers' tendency to first access the figurative, agent sense of metonyms.

While this information is known about nonliteral language processing among typically developing adults, the literature often overlooks significant individual differences. In addition to investigating language processing among neurotypical populations, it is also crucial to investigate how language processing unfolds in individuals who develop language in an atypical way, such as in people with autism spectrum disorder (ASD). Research that has examined the processing of non-literal and syntactically ambiguous language among people with ASD tends to show different patterns compared to the typically developing population. For example, Was et al. (2018) compared the eye movement patterns of adolescents diagnosed with higher-functioning autism spectrum disorder (HFASD) versus typically developing (TD) adolescents. To do so, the study manipulated the ambiguity of sentences as in (7), where each item included two critical verbs that could take either a noun phrase or a tense clause as a complement.

(7a). The social worker saw that the foster mother who accepted the little boy didn't really trust herself at all about anything. (Control - Unambiguous Sentence)

(7b). The social worker saw the foster mother who accepted the little boy didn't really trust herself at all about anything. (Target- Ambiguous Sentence)

Broadly, control participants spent more time on ambiguous sentences than individuals with HFASD, suggesting that control participants were garden-pathed by the sentences to a larger extent than participants with HFASD. The authors also observed fewer eye movements toward disambiguating regions of the sentences in HFASD participants,

suggesting that they do not comprehend ambiguous sentences as well as typically developing readers (Was et al.,2018).

There have also been studies that explored the processing patterns of the emotional impact of ironic language among TD and ASD groups. Barzy et al. (2020) conducted an experiment presenting participants with three-sentence narratives that combined criticism scenarios of both positive and negative emotions. The first sentence provided context for criticism (e.g., "John had been scared by a huge spider in the bathroom sink and immediately ran out shouting."). The second sentence contained the criticism itself, either literal or ironic (e.g., "Anna said to him, 'That was brave/cowardly.'"). The final sentence expressed the emotional response from either the victim's (John) or the protagonist's (Anna) perspective, using either positive or negative emotional words (e.g., "John thought that this was a very mean/witty remark." or "Anna had meant for this to be a very mean/witty remark."). Results suggested that TD readers experienced a two-stage processing effect, exhibiting longer reading times for ironic versus literal criticisms initially, but later showing expectations of more positive emotional responses following ironic criticism. However, the ASD readers showed no timing differences between ironic and literal conditions. This suggests they did not draw emotional valence distinctions between criticism types. These findings reveal processing differences between neurotypical and ASD groups regarding the integration of emotional context during comprehension of non-literal ironic language (Barzy et al.,2020).

Although some studies have compared participants who were diagnosed with ASD to typically developing populations, other studies have assessed participants' autistic personality traits continuously using self-report measures like the Autism Spectrum Quotient (AQ) (Baron-Cohen et al.,2001). The AQ is a questionnaire consisting of 50 statements for which participants indicate whether they definitely agree, slightly agree, slightly disagree, or

definitely disagree. These statements pertain to various autistic traits, such as poor communication and exceptional attention to detail. Example items include: I find social situations easy; I find it difficult to work out people's intentions; It does not upset me if my routine is disturbed.

McKenna et al. (2015) investigated whether differences in AQ scores were related to metonym processing among a nonclinical population. They administered the AQ to participants and divided them into high and low AQ groups based on a median split of their scores. The authors manipulated two variables: Context (literal vs metonymic interpretation) and Familiarity (familiar vs unfamiliar).

(8a). During my trip, I hitchhiked around Vietnam, but in the end I decided to rent a car…

(8b). A lot of Americans protested during Vietnam, but in the end this did not alter…

(8c). During my trip, I hitchhiked around Finland, but in the end I decided to rent a car…

(8d). A lot of Americans protested during Finland, but in the end this did not alter…

Results from this study showed a significant main effect of statement type, where all participants demonstrated relatively slower reading times for metonymic sentences compared to literal ones. Importantly, the authors also uncovered a 3-way interaction between context, familiarity, and degree of autism traits. These results suggested that lower AQ participants showed processing delays when resolving metonyms compared to literal versions. However, high AQ participants demonstrated even greater slowdowns specifically when encountering novel metonyms. Therefore, the results of this study support the hypothesis that rather than a deficit in comprehension abilities, the disproportionate processing slowdowns for novel

nonliteral items among higher AQ participants likely stem from cognitive style variations pertaining to the speed of processing information (McKenna et al.,2015).

Building upon the findings of McKenna et al. (2015), as well as Lowder et al. (2023), the goal of the current study was to examine whether individuals with higher levels of autistic traits, without a formal ASD diagnosis, process metonymic expressions differently compared to those with lower trait levels when such expressions are encountered without prior context. In particular, the aim is to determine whether neurotypical adults who report higher levels of ASD-aligned personality traits show similar or divergent metonymic comprehension patterns compared to neurotypical adults who report lower levels of these traits.

This study has three main goals. Firstly, I aimed to replicate previous findings demonstrating that place-for-institution metonyms in subject position are processed as agents, as revealed by garden-path effects for metonyms compared to inanimate controls (Lowder et al. 2023a, 2023b). Secondly, I aimed to use sentences with an introductory clause to replicate the findings of Lowder et al. (2023b) in showing processing differences on the metonyms vs inanimate nouns. Lastly, the project aimed to determine whether any of the effects found in these previous studies are modulated by individual differences, specifically in terms of autistic personality traits, as measured by the Autism Quotient (AQ). Regarding this third objective, I had two hypotheses. First, I predicted that participants who score higher on the AQ would display shorter reading times on metonyms compared to inanimate nouns. This would indicate more rapid but potentially less integrative processing for the metonym condition among those with higher AQ scores. Second, I predicted that participants with higher AQ scores would demonstrate similar reading times on the spillover region for metonyms (6a) and inanimate nouns (6c), suggesting that participants with higher levels of

autistic personality traits do not show the same differential processing difficulty for nonliteral over literal language observed in the general population.

Method

Participants

Sixty people participated in the experiment. The participants included undergraduate students at the University of Richmond, as well as other members of the campus community. Participants received course credit or a $15 gift certificate for their participation. All participants had normal or corrected-to-normal vision. Six participants reported that English was not their dominant language. These individuals were removed from all analyses, leaving a dataset of 54 participants.

Materials

Each participant was presented with 40 experimental sentences and 84 filler sentences. Experimental sentences were the same sentences used in Lowder et al. (2023b). The design crossed the factors of NP type and sentence structure. The factor NP type refers to the sentence subject, which could be a familiar metonym (6a,6b) or an inanimate noun without a metonymic sense (6c, 6d). The factor sentence structure refers to whether the sentence structure was temporarily syntactically ambiguous (6a, 6c) or unambiguous (6b, 6d). In the ambiguous condition, the first verb (e.g., “requested”) could initially be interpreted as the main verb of the sentence; however, the interpretation was always disconfirmed at the disambiguating by-phrase. The metonyms and inanimate control nouns did not differ in length (mean number of characters for metonyms = 6.8, inanimate = 6.4) or frequency (Brysbaert & New, 2009; mean log frequency for metonyms = 2.93, inanimates = 2.97), ts <1. They also did not differ in terms of concreteness or orthographic neighborhood size. The

full set of experimental items is included in Appendix A. Forty of the filler sentences were from an unrelated experiment. The remaining 44 filler sentences represented a range of structures and content.

Procedure

Sentences were presented using Experiment Builder software (SR Research). Participants' eye movements were tracked using an Eyelink 1000 as they read the items on a monitor. A forehead rest and chin rest were used to minimize head movements. At the beginning of each trial, participants were instructed to look at a fixation point that appeared on the left edge of the monitor, marking the location of where the first word of the sentence would appear. When the participant's gaze was steady, the experimenter presented the sentence. After reading each item, the participant pressed a button, at which point a true-or-false comprehension question appeared and remained on the screen until the participant responded.

After the eye-tracking portion of the experiment, participants completed that AQ (see Appendix B), as well as several language-experience questionnaires (measures of vocabulary, Author Recognition Test, and Reading Habits), which are not the focus of the current study. Participants were then thanked for their participation and debriefed.

Analysis

Data analysis focused on a common eye movement measure that indicates integration difficulties: regression-path duration. Regression-path duration is the sum of all the fixations starting with the first fixation on the region and ending when gaze advances forward from that region, accounting for any time the reader spends looking back to the earlier parts of the sentence. Three sentence regions were analyzed: the subject noun phrase, the disambiguating by-phrase, and the two-word spillover region. The example sentence below shows the subject

noun phrase in italics, the disambiguating by-phrase in bold, and the spillover region underlined.

As usual, *the hospital* requested **by the doctor** <u>was not</u> entirely ready for a full staff to begin working.

The data were analyzed using linear mixed-effects models in the lme4 package in R. Fixed effects included the experimental factors NP type (inanimate vs metonym), structure (ambiguous vs unambiguous), AQScore (mean-centered), and all interactions. Random effects included by-subjects and by-items intercepts. The AQ was scored according to the procedure described in Baron-Cohen et al. (2001), such that responses of "Definitely agree" or "slightly agree" scored 1 point on the following items: 1, 2, 4, 5, 6, 7, 9, 12, 13, 16, 18, 19, 20, 21, 22, 23, 26, 33, 35, 39, 41, 42, 43, 45, 46, whereas responses of "Definitely disagree" or "slightly disagree" scored 1 point on the following items: 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 40, 44, 47, 48, 49, 50.

Results

Mean accuracy on the comprehension questions was 96%. The results of the analyses for the three regions of the experimental sentences are reported in Table 1.

Table 1

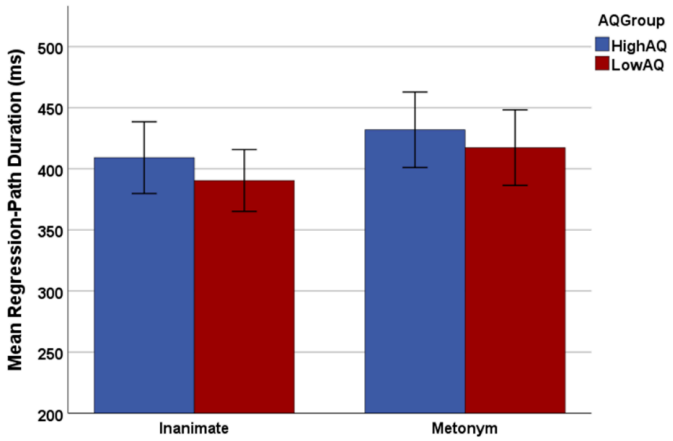
Results of the linear mixed-effects models

	Subject Noun Phrase				Disambiguating phrase				Spillover			
	Estimate	SE	*t*	*p*	Estimate	SE	*t*	*p*	Estimate	SE	*t*	*p*
Intercept	412.4665	13.2667	31.09	<2e-16	584.524	21.719	26.913	<2e-16	425.302	20.786	20.461	<2e-16
NPtype	24.358	9.3065	2.617	8.93E-03	53.681	13.413	4.002	6.50E-05	45.335	10.685	4.243	2.31E-05
Syntax	7.0284	9.3065	0.755	4.50E-01	102.998	13.419	7.676	2.55E-14	29.269	10.707	2.734	0.00632
AQScore	2.7373	12.1212	0.226	0.82223	4.259	18.918	0.225	0.8228	10.504	13.997	0.75	0.45636
Syntax: NPtype	-32.6905	18.6068	-1.757	0.07909	32.602	26.821	1.216	0.2243	18.951	10.675	0.887	0.37494
Syntax: AQScore	0.5694	9.3039	0.061	0.9512	-24.156	13.415	-1.801	0.0719	8.717	10.675	0.817	0.41427
Nptype: AQScore	2.9218	9.4808	0.308	0.7598	-3.187	13.733	-0.232	0.8165	6.139	10.978	0.559	0.57606
Syntax: Nptype: AQScore	-2.2015	18.9717	-0.116	0.90763	16.54	27.431	0.603	0.5466	-46.108	21.973	-2.098	0.03601

On the Subject Noun Phrase, there was a significant main effect of NPtype (estimate = 24.3580, $t = 2.617$, $p < 0.01$), such that there were longer reading times on metonyms versus inanimate control nouns (see Figure 1). There was no significant interaction between AQScore and NPtype, indicating that the longer reading times on metonyms were fully independent of the AQscore. The analysis also indicated a marginally significant interaction between Syntax and NPtype (estimate = -32.6905, t = -1.757, p = 0.08), such that regression path durations on the subject NP were slightly longer for ambiguous sentences compared to unambiguous sentences.

Figure 1

Regression-path duration on the subject noun phrase

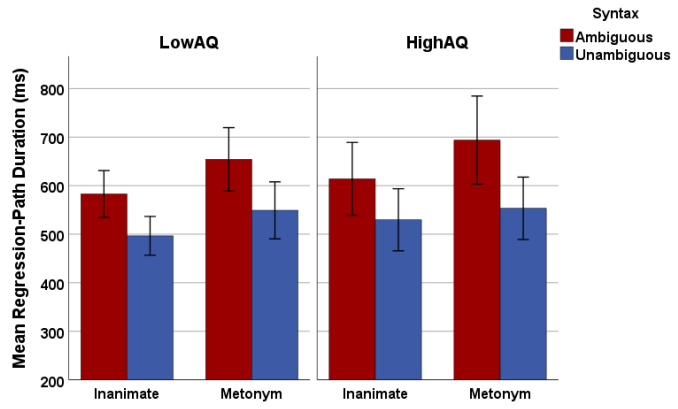


Analysis of regression-path duration on the by-phrase showed a significant main effect of Syntax (estimate = 102.998, $t = 7.676$, $p < 0.001$), showing that reading times were longer for ambiguous sentences compared to unambiguous sentences. There was also a significant main effect of NPtype (estimate = 53.681, $t = 4.002$, $p < 0.001$), such that reading times were longer for metonyms compared to inanimate control nouns (see Figure 2). Interestingly, there was also a marginally significant interaction between Syntax and

AQScore (estimate = -24.156, t = -1.801, p = 0.0719), suggesting that participants who scored higher on the AQ took longer to process ambiguous sentences.

Figure 2

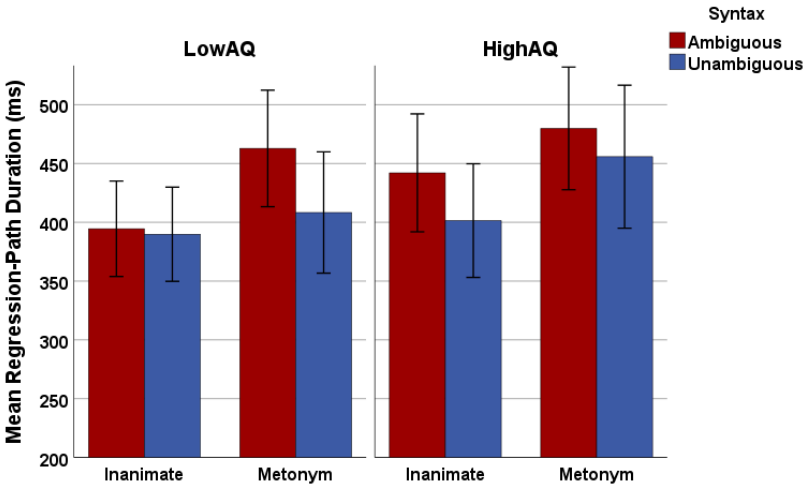
Regression-path duration on by-phrase



At the spillover region, there was a main effect of syntax (estimate = 29.269, t = 2.734, p = 0.00632), such that there were longer reading times on ambiguous sentences than unambiguous sentences. Additionally, there was also a significant main effect of NPtype (estimate = 45.335, t = 4.243, p < 0.001), indicating that metonyms took longer to process than inanimate control nouns. Importantly, there was a significant three-way interaction between NPtype, Syntax, and AQScore (estimate = -46.108, t = -2.098, p = 0.03601), suggesting that participants who scored higher on the AQ were garden-pathed for both metonym and inanimate control conditions, whereas participants scoring lower on the AQ showed larger garden-path effects when the subject was a metonym than an inanimate noun (see Figure 3).

Figure 3

Regression-path duration on the spillover region



General Discussion

Broadly, the results of this study replicate what previous studies have found regarding metonym processing. Significant main effects of the noun phrase on different regions of the sentence replicate some of the key patterns reported by Lowder et al. (2023a, 2023b). The significant main effects of noun phrase type on the subject noun phrase itself suggest that readers generally tend to spend more time processing metonyms compared to inanimate control nouns, even when the nouns are matched on a range of other lexical characteristics. The lack of an interaction with AQ scores suggests that similar effects emerge regardless of autism personality traits. Importantly, this result replicates previous findings showing a processing cost associated with accessing the figurative sense of a metonym, which aligns with the predictions of the indirect access model (Frisson & Pickering,1999; Lowder & Gordon,2013). The finding of longer regression-path durations on metonyms versus inanimate control nouns replicates the findings from Lowder et al. (2023b), indicating that readers have a bias to access the figurative sense of metonyms in subject positions. However, the bias to interpret the agent sense of nouns comes with an immediate processing cost. The

current findings also replicate results from McKenna et al. (2015), where all the participants regardless of the AQ score had slower reading times on metonyms.

On the by-phrase and spillover region, the current results showed that ambiguous sentences took longer to process than unambiguous sentences. These findings replicate the results of Lowder et al. (2023a), where the authors found significant main effects of sentence structure in several eye-tracking measures including regression-path duration. Similar to the results on the noun phrase region, the effects on the by-phrase did not interact with AQ scores, demonstrating a general processing difficulty.

A novel contribution of this study is the three-way interaction of syntax, noun phrase type, and AQ group on the spillover region. The pattern shows that for participants scoring lower on the AQ, there was a larger garden-path effect when the subject was a metonym than an inanimate noun, showing the bias to adopt the figurative sense of a metonym. These results for participants scoring lower on the AQ replicate the key findings from Lowder et al. (2023a). The results are also consistent with the results of Was et al. (2018), who showed that neurotypical control participants experienced larger garden-path effects than participants with High Functioning Autistic Spectrum Disorder (HFASD). Therefore, our non-clinical college student samples that include students with a greater degree of autistic personality traits exhibit similar patterns to the HFASD population in being less likely to experience garden-path effects from metonyms.

Interestingly, participants scoring higher on the AQ were garden-pathed in both the metonym and inanimate conditions to a similar degree. This pattern has similarities to Barzy et al. (2020), which suggests that there are different processing patterns for individuals with ASD and typically developing participants. However, they found that individuals with ASD process non-literal language in the same way as literal language. This suggests that those who

tend to have more autistic personality traits are less likely to be affected by the processing cost that metonyms induce, as seen in the three-way interaction that we found. Was et al. (2018) also found fewer eye movements towards disambiguating phrases for their HFASD participants compared to their control participants. For sentences in the current experiment with an inanimate sentence subject (e.g., *the equipment requested*…), the lack of a figurative sense of the noun could serve as useful disambiguating information that might help readers block the garden-path effect. The three-way interaction on the spillover region suggests that participants scoring lower on the AQ did use this information to their advantage more so than the participants scoring higher on the AQ. The results are consistent with Was et al. (2018), demonstrating that individuals with a higher degree of autistic personality traits may not use this information in the same way as individuals with a lower degree of autistic personality traits, potentially causing them to be garden-pathed for inanimate nouns that lack figurative sense as well.

McKenna et al. (2015) discussed that one difference between participants who scored higher and lower on the AQ in their study is the variability in processing speed, as evidenced by the disproportionate processing slowdowns for nonliteral items in Higher AQ participants. However, results from the current study suggest that the explanation may have more to do with different processing patterns as opposed to differences in processing speed. As seen in Figure 3, processing patterns on the spillover region were significantly different such that participants with more autistic personality traits were garden-pathed in both metonyms and inanimate nouns, whereas those with fewer autistic traits were garden-pathed only in metonymic conditions.

Overall, this study showed that individual differences in personality traits can partly explain variability in sentence processing patterns. There is very little previous work suggesting that personality characteristics are associated with differences in sentence processing patterns. As such, the results of this study suggest that future attempts to relate other types of personality characteristics to other types of language processing might be particularly fruitful. Additionally, this line of research could potentially help the development of more personalized and effective interventions for individuals with language-related disorders or difficulties.

References

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental disorders*, *31*(1), 5–17. https://doi.org/10.1023/a:1005653411471

Barzy, M., Filik, R., Williams, D., & Ferguson, H. J. (2020). Emotional processing of ironic versus literal criticism in autistic and nonautistic adults: Evidence from eye‐tracking. *Autism Research*, *13*(4), 563-578. doi:10.1002/aur.2272

Brysbaert, M., & New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods, , 41*(4), 977–990. https://doi.org/10.3758/BRM.41.4.977

Frisson, S., & Pickering, M. J. (1999). The processing of metonymy: Evidence from eye movements. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*(6), 1366–1383. https://doi.org/10.1037/0278-7393.25.6.1366

Fishbein, J., & Harris, J. A. (2014). Making sense of Kafka: Structural biases induce early sense commitment for metonyms. *Journal of Memory and Language, 76,* 94–112. https://doi.org/10.1016/j.jml.2014.06.005

Hauptman, M., Blank, I., & Fedorenko, E. (2023). Non-literal language processing is jointly supported by the language and theory of mind networks: Evidence from a novel meta-analytic fMRI approach. *Cortex*, *162*, 96–114. https://doi.org/10.1016/j.cortex.2023.01.013

Littlemore, J. (2017). Metonymy. In B. Dancygier (Ed.), *The Cambridge Handbook of Cognitive Linguistics* (Cambridge Handbooks in Language and Linguistics).

Lowder, M. W., & Gordon, P. C. (2013). It's hard to offend the college: Effects of sentence structure on figurative-language processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*(4), 993–1011. https://doi.org/10.1037/a0031671

Lowder, M. W., Zhou, A., & Gordon, P. C. (2023a). The lab discovered: Place-for-institution metonyms appearing in subject position are processed as agents. *Journal of Experimental Psychology: Learning, Memory, and Cognition.* Advance online publication. https://doi.org/10.1037/xlm0001314

Lowder, M. W., Moe, M., & Evdokimov, A. (2023b). Immediate processing costs for place-for-institution metonyms appearing as sentence subjects [Poster presentation]. Human Sentence Processing Conference, University of Pittsburgh, Pittsburgh, PA, United States

McKenna, P. E., Glass, A., Rajendran, G., & Corley, M. (2015). Strange words: Autistic traits and the processing of non-literal language. *Journal of Autism and Developmental Disorders*, *45*(11), 3606–3612. https://doi.org/10.1007/s10803-015-2508-4

Was, C. A., Sansosti, F. J., & Graham, E. (2018). Eye movements while processing syntactically ambiguous sentences in adolescents with autism spectrum disorders: Preliminary outcomes and benchmarking data. *Global Journal of Intellectual and Developmental Disabilities*, *4*(4), 555645. https://doi.org/10.19080/GJIDD.2018.04.555645

Appendix

Appendix A

Experimental items

1a. To our surprise, the court acknowledged by the lawyer turned out to be unreliable.
1b. To our surprise, the court that was acknowledged by the lawyer turned out to be unreliable.
1c. To our surprise, the evidence acknowledged by the lawyer turned out to be unreliable.
1d. To our surprise, the evidence that was acknowledged by the lawyer turned out to be unreliable.

2a. As we expected, the store paid by the artist was located in an old building downtown.
2b. As we expected, the store that was paid by the artist was located in an old building downtown.
2c. As we expected, the bill paid by the artist was located in an old building downtown.
2d. As we expected, the bill that was paid by the artist was located in an old building downtown.

3a. Quite understandably, the academy assessed by the teacher received extremely good reviews.
3b. Quite understandably, the academy that was assessed by the teacher received extremely good reviews.
3c. Quite understandably, the article assessed by the teacher received extremely good reviews.
3d. Quite understandably, the article that was assessed by the teacher received extremely good reviews.

4a. Within two hours, the gallery identified by the victim became an important clue for solving the mystery.
4b. Within two hours, the gallery that was identified by the victim became an important clue for solving the mystery.
4c. Within two hours, the jewelry identified by the victim became an important clue for solving the mystery.
4d. Within two hours, the jewelry that was identified by the victim became an important clue for solving the mystery.

5a. As usual, the hospital requested by the doctor was not entirely ready for a full staff to begin working.
5b. As usual, the hospital that was requested by the doctor was not entirely ready for a full staff to begin working.
5c. As usual, the equipment requested by the doctor was not entirely ready for a full staff to begin working.
5d. As usual, the equipment that was requested by the doctor was not entirely ready for a full staff to begin working.

6a. Fortunately, the headquarters announced by the executive would attract many workers to the area.
6b. Fortunately, the headquarters that was announced by the executive would attract many workers to the area.
6c. Fortunately, the software announced by the executive would attract many workers to the area.
6d. Fortunately, the software that was announced by the executive would attract many workers to the area.

7a. As in previous years, the prison targeted by the government was deemed unsafe for the public.
7b. As in previous years, the prison that was targeted by the government was deemed unsafe for the public.
7c. As in previous years, the substance targeted by the government was deemed unsafe for the public.
7d. As in previous years, the substance that was targeted by the government was deemed unsafe for the public.

8a. In line with predictions, the embassy captured by the enemy marked the starting point of the war.
8b. In line with predictions, the embassy that was captured by the enemy marked the starting point of the war.
8c. In line with predictions, the valley captured by the enemy marked the starting point of the war.
8d. In line with predictions, the valley that was captured by the enemy marked the starting point of the war.

9a. Unfortunately, the school described by the parents as unsafe remained in use for an additional five years.
9b. Unfortunately, the school that was described by the parents as unsafe remained in use for an additional five years.
9c. Unfortunately, the bus described by the parents as unsafe remained in use for an additional five years.
9d. Unfortunately, the bus that was described by the parents as unsafe remained in use for an additional five years.

10a. Regrettably, the university selected by the student was known for making controversial statements.
10b. Regrettably, the university that was selected by the student was known for making controversial statements.
10c. Regrettably, the textbook selected by the student was known for making controversial statements.
10d. Regrettably, the textbook that was selected by the student was known for making controversial statements.

11a. In all likelihood, the palace secured by the guard was unknown in most parts of the world.

11b. In all likelihood, the palace that was secured by the guard was unknown in most parts of the world.
11c. In all likelihood, the painting secured by the guard was unknown in most parts of the world.
11d. In all likelihood, the painting that was secured by the guard was unknown in most parts of the world.

12a. In our opinion, the institute discovered by the celebrity did not deserve to be selected for the prize.
12b. In our opinion, the institute that was discovered by the celebrity did not deserve to be selected for the prize.
12c. In our opinion, the recipe discovered by the celebrity did not deserve to be selected for the prize.
12d. In our opinion, the recipe that was discovered by the celebrity did not deserve to be selected for the prize.

13a. For some reason, the consulate presented by the ambassador received a lot of bad press.
13b. For some reason, the consulate that was presented by the ambassador received a lot of bad press.
13c. For some reason, the solution presented by the ambassador received a lot of bad press.
13d. For some reason, the solution that was presented by the ambassador received a lot of bad press.

14a. As custom dictated, the convent blessed by the priest was popular in the local community.
14b. As custom dictated, the convent that was blessed by the priest was popular in the local community.
14c. As custom dictated, the bible blessed by the priest was popular in the local community.
14d. As custom dictated, the bible that was blessed by the priest was popular in the local community.

15a. To our relief, the college studied by the visitor was prepared for the mandatory software updates.
15b. To our relief, the college that was studied by the visitor was prepared for the mandatory software updates.
15c. To our relief, the computer studied by the visitor was prepared for the mandatory software updates.
15d. To our relief, the computer that was studied by the visitor was prepared for the mandatory software updates.

16a. As anticipated, the treasury addressed by the secretary later became quite valuable to investors.
16b. As anticipated, the treasury that was addressed by the secretary later became quite valuable to investors.
16c. As anticipated, the coin addressed by the secretary later became quite valuable to investors.
16d. As anticipated, the coin that was addressed by the secretary later became quite valuable to investors.

17a. Interestingly, the monastery respected by the community was written about often in the newspapers.
17b. Interestingly, the monastery that was respected by the community was written about often in the newspapers.
17c. Interestingly, the statue respected by the community was written about often in the newspapers.
17d. Interestingly, the statue that was respected by the community was written about often in the newspapers.

18a. Quite reasonably, the nursery remembered by the babysitter was photographed after the major lawsuit.
18b. Quite reasonably, the nursery that was remembered by the babysitter was photographed after the major lawsuit.
18c. Quite reasonably, the bottle remembered by the babysitter was photographed after the major lawsuit.
18d. Quite reasonably, the bottle that was remembered by the babysitter was photographed after the major lawsuit.

19a. In a turn of events, the resort inspected by the contractor was found to be unsuitable for the business.
19b. In a turn of events, the resort that was inspected by the contractor was found to be unsuitable for the business.
19c. In a turn of events, the brick inspected by the contractor was found to be unsuitable for the business.
19d. In a turn of events, the brick that was inspected by the contractor was found to be unsuitable for the business.

20a. As we had hoped, the restaurant found by the critic was finally ready for the grand opening.
20b. As we had hoped, the restaurant that was found by the critic was finally ready for the grand opening.
20c. As we had hoped, the menu found by the critic was finally ready for the grand opening.
20d. As we had hoped, the menu that was found by the critic was finally ready for the grand opening.

21a. Before we knew it, the shop held by the criminal needed to be rescued by the police.
21b. Before we knew it, the shop that was held by the criminal needed to be rescued by the police.
21c. Before we knew it, the purse held by the criminal needed to be rescued by the police.
21d. Before we knew it, the purse that was held by the criminal needed to be rescued by the police.

22a. Miraculously, the station featured by the website was starting to attract many more customers.
22b. Miraculously, the station that was featured by the website was starting to attract many more customers.

22c. Miraculously, the ticket featured by the website was starting to attract many more customers.
22d. Miraculously, the ticket that was featured by the website was starting to attract many more customers.

23a. Quite obviously, the supermarket accepted by the company was long overdue for some changes.
23b. Quite obviously, the supermarket that was accepted by the company was long overdue for some changes.
23c. Quite obviously, the product accepted by the company was long overdue for some changes.
23d. Quite obviously, the product that was accepted by the company was long overdue for some changes.

24a. By chance, the theatre volunteered by the director for the show was available for the entire summer.
24b. By chance, the theatre that was volunteered by the director for the show was available for the entire summer.
24c. By chance, the guitar volunteered by the director for the show was available for the entire summer.
24d. By chance, the guitar that was volunteered by the director for the show was available for the entire summer.

25a. Without a doubt, the warehouse pursued by the architect was older than anyone had anticipated.
25b. Without a doubt, the warehouse that was pursued by the architect was older than anyone had anticipated.
25c. Without a doubt, the sculpture pursued by the architect was older than anyone had anticipated.
25d. Without a doubt, the sculpture that was pursued by the architect was older than anyone had anticipated.

26a. Disastrously, the bank released by the businessman put additional strain on the financial situation.
26b. Disastrously, the bank that was released by the businessman put additional strain on the financial situation.
26c. Disastrously, the cash released by the businessman put additional strain on the financial situation.
26d. Disastrously, the cash that was released by the businessman put additional strain on the financial situation.

27a. Surprisingly, the clinic wanted by the patient was the cause of a conflict that began in the waiting room.
27b. Surprisingly, the clinic that was wanted by the patient was the cause of a conflict that began in the waiting room.
27c. Surprisingly, the bandage wanted by the patient was the cause of a conflict that began in the waiting room.

27d. Surprisingly, the bandage that was wanted by the patient was the cause of a conflict that began in the waiting room.

28a. Unquestionably, the café enjoyed by the couple seemed like the perfect choice for the wedding reception.
28b. Unquestionably, the café that was enjoyed by the couple seemed like the perfect choice for the wedding reception.
28c. Unquestionably, the cake enjoyed by the couple seemed like the perfect choice for the wedding reception.
28d. Unquestionably, the cake that was enjoyed by the couple seemed like the perfect choice for the wedding reception.

29a. Little did we know, the casino watched by the detective was possibly involved in illegal activity.
29b. Little did we know, the casino that was watched by the detective was possibly involved in illegal activity.
29c. Little did we know, the notebook watched by the detective was possibly involved in illegal activity.
29d. Little did we know, the notebook that was watched by the detective was possibly involved in illegal activity.

30a. As we all knew, the cinema discussed by the mayor was a highlight of the small town.
30b. As we all knew, the cinema that was discussed by the mayor was a highlight of the small town.
30c. As we all knew, the river discussed by the mayor was a highlight of the small town.
30d. As we all knew, the river that was discussed by the mayor was a highlight of the small town.

31a. Unsurprisingly, the factory preferred by the investor was in Florida near the beach.
31b. Unsurprisingly, the factory that was preferred by the investor was in Florida near the beach.
31c. Unsurprisingly, the vacation preferred by the investor was in Florida near the beach.
31d. Unsurprisingly, the vacation that was preferred by the investor was in Florida near the beach.

32a. To our amazement, the garage searched by the owner had money hidden near the window.
32b. To our amazement, the garage that was searched by the owner had money hidden near the window.
32c. To our amazement, the truck searched by the owner had money hidden near the window.
32d. To our amazement, the truck that was searched by the owner had money hidden near the window.

33a. As had happened before, the gym ignored by the client was overrated and too expensive.
33b. As had happened before, the gym that was ignored by the client was overrated and too expensive.
33c. As had happened before, the treadmill ignored by the client was overrated and too expensive.

33d. As had happened before, the treadmill that was ignored by the client was overrated and too expensive.

34a. With our approval, the synagogue dedicated by the rabbi became a symbol of peace and love.
34b. With our approval, the synagogue that was dedicated by the rabbi became a symbol of peace and love.
34c. With our approval, the candle dedicated by the rabbi became a symbol of peace and love.
34d. With our approval, the candle that was dedicated by the rabbi became a symbol of peace and love.

35a. Apparently, the hostel welcomed by the governor attracted many young visitors to the state.
35b. Apparently, the hostel that was welcomed by the governor attracted many young visitors to the state.
35c. Apparently, the publicity welcomed by the governor attracted many young visitors to the state.
35d. Apparently, the publicity that was welcomed by the governor attracted many young visitors to the state.

36a. Eventually, the hotel authorized by the inspector for the job was given the necessary security clearance.
36b. Eventually, the hotel that was authorized by the inspector for the job was given the necessary security clearance.
36c. Eventually, the phone authorized by the inspector for the job was given the necessary security clearance.
36d. Eventually, the phone that was authorized by the inspector for the job was given the necessary security clearance.

37a. In an instant, the club introduced by the announcer reminded everyone of an earlier era.
37b. In an instant, the club that was introduced by the announcer reminded everyone of an earlier era.
37c. In an instant, the song introduced by the announcer reminded everyone of an earlier era.
37d. In an instant, the song that was introduced by the announcer reminded everyone of an earlier era.

38a. As we had feared, the asylum designated by the official as safe was still regarded with suspicion.
38b. As we had feared, the asylum that was designated by the guard as safe was still regarded with suspicion.
38c. As we had feared, the water designated by the official as safe was still regarded with suspicion.
38d. As we had feared, the water that was designated by the official as safe was still regarded with suspicion.

39a. Most likely, the jail classified by the agent was involved in a top-secret government operation.

39b. Most likely, the jail that was classified by the agent was involved in a top-secret government operation.
39c. Most likely, the recorder classified by the agent was involved in a top-secret government operation.
39d. Most likely, the recorder that was classified by the agent was involved in a top-secret government operation.

40a. Without permission, the library celebrated by the deputy made several bold claims about the election.
40b. Without permission, the library that was celebrated by the deputy made several bold claims about the election.
40c. Without permission, the pamphlet celebrated by the deputy made several bold claims about the election.
40d. Without permission, the pamphlet that was celebrated by the deputy made several bold claims about the election.

Appendix B

Autism-Spectrum Quotient

Mark one response that best describes how strongly each item applies to you:

	Definitely Agree	**Slightly Agree**	**Slightly Disagree**	**Definitely Disagree**
1. I prefer to do things with others rather than on my own.				
2. I prefer to do things the same way over and over again.				
3. If I try to imagine something, I find it very easy to create a picture in my mind.				
4. I frequently get so strongly absorbed in one thing that I lose sight of other things.				
5. I often notice small sounds when others do not.				
6. I usually notice car number plates or similar strings of information.				
7. Other people frequently tell me that what I've said is impolite, even though I think it is polite.				
8. When I'm reading a story, I can easily imagine what the characters might look like.				
9. I am fascinated by dates.				
10. In a social group, I can easily keep track of several different people's conversations.				
11. I find social situations easy.				
12. I tend to notice details that others do not.				
13. I would rather go to a library than to a party.				
14. I find making up stories easy.				
15. I find myself drawn more strongly to people than to things.				
16. I tend to have very strong interests, which I get upset about if I can't pursue.				
17. I enjoy social chitchat.				
18. When I talk, it isn't always easy for others to get a word in edgewise.				
19. I am fascinated by numbers.				
20. When I'm reading a story, I find it difficult to work out the characters' intentions.				

21. I don't particularly enjoy reading fiction.				
22. I find it hard to make new friends.				
23. I notice patterns in things all the time.				
24. I would rather go to the theater than to a museum.				
25. It does not upset me if my daily routine is disturbed.				
26. I frequently find that I don't know how to keep a conversation going.				
27. I find it easy to "read between the lines" when someone is talking to me.				
28. I usually concentrate more on the whole picture, rather than on the small details.				
29. I am not very good at remembering phone numbers.				
30. I don't usually notice small changes in a situation or a person's appearance.				
31. I know how to tell if someone listening to me is getting bored.				
32. I find it easy to do more than one thing at once.				
33. When I talk on the phone, I'm not sure when it's my turn to speak.				
34. I enjoy doing things spontaneously.				
35. I am often the last to understand the point of a joke.				
36. I find it easy to work out what someone is thinking or feeling just by looking at their face.				
37. If there is an interruption, I can switch back to what I was doing very quickly.				
38. I am good at social chitchat.				
39. People often tell me that I keep going on and on about the same thing.				
40. When I was young, I used to enjoy playing games involving pretending with other children.				

41. I like to collect information about categories of things (e.g., types of cars, birds, trains, plants).				
42. I find it difficult to imagine what it would be like to be someone else.				
43. I like to carefully plan any activities I participate in.				
44. I enjoy social occasions.				
45. I find it difficult to work out people's intentions.				
46. New situations make me anxious.				
47. I enjoy meeting new people.				
48. I am a good diplomat.				
49. I am not very good at remembering people's date of birth.				
50. I find it very easy to play games with children that involve pretending.				