RECEPTIVE VOCABULARY KNOWLEDGE IN INDIVIDUALS WITH AUTISM AS ASSESSED BY EYE MOVEMENTS, PUPILLARY DILATION, AND EVENT-RELATED POTENTIALS

Kerry Ledoux[1,], Erin J. Pickett[1,], Laura V. Van Droof[1,], Esteban Buz[1,], Nia M. Billings[1,], & Barry Gordon[1,2]

[1]*Cognitive Neurology/Neuropsychology, Department of Neurology and* [2]*Department of Cognitive Science, Johns Hopkins University*

INTRODUCTION

Classically, approximately 50% of individuals affected by autism fail to develop useful speech, and many of these individuals never learn to communicate in any functional way [1]. An important, yet difficult to address, question about such individuals is whether this lack of expressive ability is necessarily accompanied by an equally severe deficit in receptive language knowledge. Little rigorous research has been directed at this possibility, both because of the difficulty of working with such low-functioning participants, and because of the insensitivity of most traditional behavioral methodologies. Recently, however, several experimental methodologies – eye movement monitoring, pupillary dilation monitoring, and the N400 component of scalp-recorded event-related potentials – have been developed and refined to the point that they may prove sensitive enough to provide reliable evidence of such comprehension, even in the absence of more traditional behavioral responses such as speech and gesturing.

Eye movement monitoring (EM): Eye movements typically reflect current cognitive operations. For example, participants will look at objects in a display as they hear those objects named auditorily. Studies of normally developing children have suggested that such eye movements become faster and more precise as children learn the meanings of spoken words [2].

Pupillary dilation monitoring (PD): Task-specific changes in pupillary diameter that are time-locked to the onset of events (stimuli or responses) have long been associated with attentional engagement and information processing. Pupillary dilation has been shown to increase with task difficulty in many tasks, and has thus been taken as a measure of resource recruitment [3].

Event-related potentials (ERPs): The N400 component of ERP waveforms has been associated with semantic processing, such that words or pictures that are semantically congruent with their proceeding context elicit a smaller-amplitude N400 than words or pictures that are incongruent; this difference has been called the N400 congruity effect. Connolly and colleagues [4] developed a paradigm that takes advantage of the N400 congruity effect to determine receptive vocabulary knowledge in the absence of an overt behavioral response. Participants see a picture on the computer screen and hear a word that either matches (congruous condition) or does not match (incongruous condition) the picture shown. Testing with normal adults, normal children, adults with aphasia, and a child with cerebral palsy (for whom motor activity, and thus behavioral response, was limited) has shown a larger N400 to the auditory word in the incongruous condition than in the congruous condition – but only for words that were within the participant's vocabulary level. Critically, this effect was shown for individual participants as well as in the grand-averages across participants.

We tested the hypothesis that these relatively implicit measures of cognitive processing would prove sensitive to receptive vocabulary knowledge in nonverbal individuals, even in the absence of more traditional behavioral responses. We first demonstrated the use of these measures in three populations in whom behavioral responses were expected to be reliable: normal adults, normally developing children, and high-functioning individuals with autism.

PARTICIPANTS

Normal adults, normally developing children, and high-functioning individuals with autism:
- Right-handed native English speakers
- Normal/corrected-to-normal vision
- Behavioral responses used to determine "known" items

Individuals with autism:
- Clinical diagnosis confirmed via administration of ADOS and ADI-R
- High-functioning individuals with autism differentiated from normally-developing children via the ASSQ
- Low-functioning individuals with autism differentiated via IQ; low-functioning individuals functionally nonverbal
- "Known" items determined for low-functioning individuals via parental/caregiver report

Population	Tested to Date	Useable Data to Date			Target
		EM/PD	ERP	Both	
Normal adults	45	35	25	18	20
Normally developing children	10	9	1	1	20
High-functioning individuals with autism	2	1	1	1	20
Low-functioning individuals with autism	3	2	1	1	10

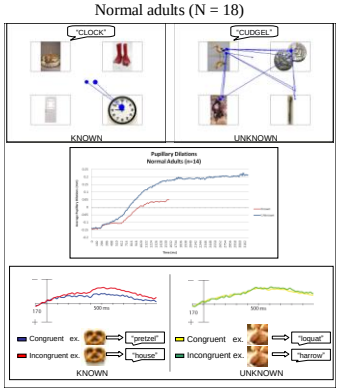
METHOD

Stimuli:
- 160 words
  - 80 "known" (ex. *airplane* and *camera*)
  - 80 "unknown" (ex. *agouti* and *cainito*)
- High-resolution digital photos, digital audio recordings
- Pretesting with a separate group of normal adults to ensure suitability of images as representations of concepts

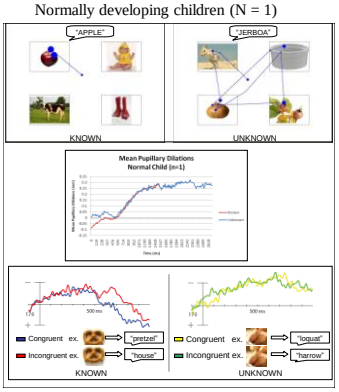
Tasks:
- Forced-choice task (EM/PD): participants are asked to use the mouse to select one of the four pictures presented simultaneously on the computer screen after hearing one of the objects named
- Congruity task (ERP): a picture is presented on the computer screen, accompanied by the auditory presentation of a single word, which matches (congruous condition) or does not match (incongruous condition) the pictured item. Participants are asked to push a button to indicate whether the auditory word and picture match.

Equipment:
- EM/PD: Applied Scientific Laboratories Model 504 Eye-Tracking System
- ERP: Electrical Geodesics Inc. GES 300 EEG System with 256-channel Hydrocel Geodesic Sensor Nets

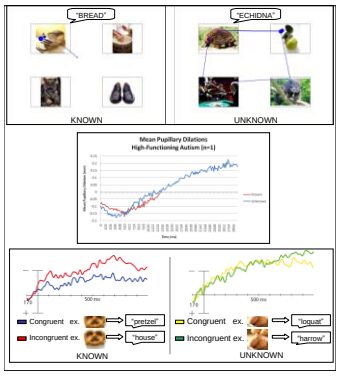
Normal adults (N = 18)



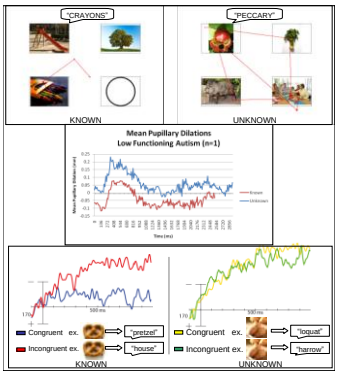
Normally developing children (N = 1)



High-functioning individuals with autism (N = 1)



Low-functioning individuals with autism (N = 1)



DISCUSSION

In all three populations capable of reliable behavioral responses (normal adults, normally developing children, and high-functioning children with autism), our results indicate that the implicit techniques provide valid measures of receptive knowledge. All three measures (eye movement monitoring, pupillary dilation monitoring, and ERPs) appear capable of differentiating known from unknown words, as compared to the criterion of behavioral responses. Specifically, eye movements were faster to, and eyes fixated longer on, the matching picture in the forced-choice task for known words relative to unknown words; pupillary dilation was greater from baseline for unknown words, relative to known words; and the N400 congruency effect was observed for known words, but not for unknown words. Thus, these data support the validity of these techniques and our experimental design.

Our preliminary testing of low-functioning participants with autism also suggests that these implicit techniques provide valid measures of receptive knowledge even in the absence of behavioral responses. All three appear capable of differentiating known from unknown words within this group, in that the preliminary results for this low-functioning individual with autism were remarkably similar to those observed for normal adults, normally-developing children, and a high-functioning individual with autism.

The demonstration of receptive abilities in nonverbal individuals would lay a foundation upon which we might better understand their baseline abilities for communication and for comprehension. Knowing that an individual can understand language even when he or she does not speak might support the development of more intensive speech and language therapies, using a broader range of modalities, to capitalize on that individual's functional preferences or strengths. We believe that our results provide an initial demonstration of such abilities in a group in which such knowledge has traditionally been difficult to assess.

REFERENCES

1. Prizant, B.M. (1996). Brief report: Communication, language, social, and emotional development. *Journal of Autism and Developmental Disorders, 26*, 173-178.

2. Swingley, D., & Fernald, A. (2002). Recognition of words referring to present and absent objects by 24-month-olds. *Journal of Memory and Language, 46*, 39-56.

3. Beatty, J., & Lucero-Wagoner, B. (2000). The pupillary system. In J.T. Cacioppo, L.G. Tassinary, G.G. Berntson (Eds.), *Handbook of psychophysiology*, 2nd edition (pp. 142-162). New York, NY: Cambridge University Press.

4. Byrne, J.M., et al. (1999). Brain activity and language assessment using event-related potentials: Development of a clinical protocol. *Developmental Medicine and Child Neurology, 41*, 740-747.

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