Biological Psychology 119 (2016) 210–215

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Response to own name in children: ERP study of auditory social information processing

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ARTICLE INFO

Article history:
Received 22 December 2015
Received in revised form 5 July 2016
Accepted 20 July 2016
Available online 22 July 2016

Keywords:
Name
P300
Social
Memory
Familiarity

ABSTRACT

Auditory processing is an important component of cognitive development, and names are among the most frequently occurring receptive language stimuli. Although own name processing has been examined in infants and adults, surprisingly little data exist on responses to own name in children. The present ERP study examined spoken name processing in 32 children (M = 7.85 years) using a passive listening paradigm. Our results demonstrated that children differentiate own and close other's names from unknown names, as reflected by the enhanced parietal P300 response. The responses to own and close other names did not differ between each other. Repeated presentations of an unknown name did not result in the same familiarity as the known names. These results suggest that auditory ERPs to known/unknown names are a feasible means to evaluate complex auditory processing without the need for overt behavioral responses.

1. Introduction

Auditory processing is an important component of cognitive development. Numerous studies have demonstrated that deficits in auditory processing are associated with learning disabilities, specific language impairment, and some of the social-communication difficulties in autism (e.g., Hämäläinen, Salminen, & Leppanen, 2013; McArthur & Castles, 2013; O'Connor, 2012). Evaluating auditory processing beyond hearing and basic speech sound discrimination can yield insights about more complex processes including language, attention, memory, and social-emotional functioning.

Names are among the most frequently occurring receptive language stimuli (Holeckova, Fischer, Giard, Delpuech, & Morlet, 2006; Holeckova et al., 2008) known for their attention-grabbing characteristics, and therefore would be an effective means to assess the extent of inherent attention to and processing of the auditory input in children. Response to own spoken name can also serve as an indicator of social-emotional functioning (e.g., Baranek, 1999; Yirmiya et al., 2006; Zwaigenbaum et al., 2005) because names are typically used to initiate, maintain, or terminate social exchange. Furthermore, own names are one of the most basic forms of language and have comparable significance across all participants (Holeckova et al., 2008; Tamura et al., 2015).

Response to one's own name develops early in life. Infants as young as 4 months prefer to listen to their own rather than other names (Mandel, Jusczyk, & Pisoni, 1995), which can help guide attention to events in their environment (Parise, Friederici, & Striano, 2010). By adulthood, own names elicit a highly preferential response that may be detected even without explicit instructions to attend (e.g., Eichenlaub, Ruby, & Morlet, 2012) and in subjects with altered state of consciousness (e.g., asleep: Perrin, Garcia-Larrea, Mauguière, & Bastuji, 1999; brain damage: Perrin et al., 2006; Laureys, Perrin, & Brédart, 2007; Wang et al., 2015). Conversely, the lack of consistent response to own name has been frequently reported in individuals with developmental disabilities (e.g., autism: Nadig et al., 2007; Cygan, Tacikowski, Ostaszewski, Chojnicka, & Nowicka, 2014; severe intellectual disability: Tamura et al., 2015). Thus, spoken names are an attractive stimulus for examining auditory processing across the lifespan and range of functioning.

Although own name processing has been examined in infants and adults, surprisingly little data exist on responses to own name in children. In infancy, own name offers a gateway to language learning (e.g., Bortfeld, Morgan, Golinkoff, & Rathbun, 2005) and communicative development (Csibra, 2010) because it is one of the most frequently experienced and therefore recognizable spoken

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http://dx.doi.org/10.1016/j.biopsycho.2016.07.016
0301-0511/

words. By adulthood, one's name becomes intrinsically meaningful through its connection to self-concept. However, it is unknown whether significant developmental changes in social, communicative, and cognitive skills that occur during childhood also affect processing of own names. The present study was designed to address this gap in knowledge.

Behavioral responses could provide general information about the children's reaction to their own name, but could also be confounded by motivational, attentional, and social factors. Therefore, we chose to examine brain responses to names. Event-related potentials (ERPs) reflect changes in ongoing electrical brain activity in response to a stimulus. They offer a non-invasive and relatively inexpensive (e.g., compared to other neuroimaging methods) means to examine information processing with high temporal precision across multiple stages, from sensory detection and perception to more complex attention, memory, and affective processes. Prior ERP studies of name processing using both visual (printed names) and auditory (spoken) stimuli examined multiple ERP responses and concluded that own name detection is most consistently reflected in the increased amplitude of the parietal P300.

Own names elicited larger parietal P300 responses than stranger names across paradigms that required an active response (e.g., familiar/unfamiliar classification or simple detection; e.g., Cygan et al., 2014; Kotlewska & Nowicka, 2015; Tacikowski & Nowicka, 2010) or passive exposure (e.g., Eichenlaub et al., 2012; Folmer & Yingling, 1997), including during sleep (Perrin et al., 1999). Earlier components, such as P200 and N250, showed sensitivity to own vs. other names using visual stimulus presentation (e.g., Tacikowski, Jednoróg, Marchewka, & Nowicka, 2011; Tacikowski, Cygan, & Nowicka, 2014), while P1/N1 response did not vary across specific name categories in either auditory or visual paradigms (Höller et al., 2011; Perrin et al., 1999, 2006; Tacikowski et al., 2014). The auditory mismatch negativity (MMN) responses were observed for names contrasted with tones (Holeckova et al., 2006, 2008), but this effect could be driven by differences in the stimulus type (speech vs. tone) in addition to the name-specific effects.

The increased positive parietal amplitude to own vs. other names overlaps in time and space with several ERP components, including the P300 (aka P3b) known to be sensitive to the attentional and memory demands (Polich, 2007), the late positive potential (LPP), reflecting affective processing (Hajcak, MacNamara, & Olvet, 2010; Sabatinelli, Keil, Frank, & Lang, 2013), and posterior old/new effect (Rugg & Curran, 2007), associated with stimulus recognition and recall processes. Indeed, the reported parietal response to own vs. other names could be driven by greater familiarity of one's own name, the perceived self-relevance of the stimuli (Fan et al., 2013) as well as by the number of repetitions during the study (Hirata et al., 2011; Höller et al., 2011; Tacikowski et al., 2011). While keeping these possible different functional interpretations in mind, we will refer to the parietal response as the "P300" for the ease of comparison with the previously published results.

Because comparable P300 effects were observed in studies requiring active participation and passive listening, we selected a passive listening paradigm for the present study. Our choice was motivated by the desire to examine the inherent attention to auditory inputs and by the need to keep the task simple enough to be suitable for future use in younger children, infants, and individuals with limited motor and/or intellectual abilities.

Although several prior studies used a combination of the first and last name as the stimuli (Cygan et al., 2014; Tacikowski & Nowicka, 2010; Tacikowski, Brechmann, & Nowicka, 2013), we chose to include just the first name because it had been more commonly used in auditory studies of name processing and is more likely to be familiar to children. The children's parents also provided the name of a close other person, with whom the child has a positive relationship. We did not use the parents' names because children rarely address or hear others address their parents by the first name. This choice also was expected to contribute to more comparable levels of familiarity of the close other name across subjects.

In the context of existing evidence demonstrating that repeated exposure within a test session may lead to increased brain responses to novel and unfamiliar names (e.g., Tacikowski et al., 2011), our paradigm included two unknown name conditions: repeated presentation of a single stranger name and a diverse set of novel names presented once. This design allowed to control for the possible repetition effects, examine the effects of pre-experimental familiarity vs. within-session familiarization due to stimulus exposure, and consider the impact of the number of unknown names on the ERPs to one's own name. In 5-month-old infants, the use of multiple unknown names as a contrast to the subject's own name resulted in the loss of the significant ERP enhancement for the own name compared to the single stranger name condition (Parise et al., 2010). However, the older children enrolled in our study were expected to have more experience with their own names as compared to infant participants. Additionally, including multiple unknown names provided greater variability in the auditory input, which was expected to maintain subjects' interest and reduce habituation to the stimuli. The resulting combination of the stimuli (own name, close other, repeated stranger, and novel names) also led to the relatively less frequent presentation of the own name compared to all other stimuli. This was expected to increase the likelihood of observing the increased P300 response to own name, as several prior studies in adults using a passive paradigm with equiprobable presentation of own, familiar, and novel names reported no significant condition differences in the ERPs (e.g., Hirata et al., 2011; Höller et al., 2011).

In line with the previously reported data, we hypothesized that in children, own and close other's names will elicit larger parietal P300 responses than unknown names. If name processing reflects personal emotional connection, then the repeated stranger name should be associated with smaller P300 amplitudes than own or close other name. Conversely, comparable responses to all repeated names vs. unknown names presented once will indicate general attention to and familiarization with the stimulus content.

2. Method

2.1. Participants

Thirty-two typically developing children (15 female), age 4–12 years (M = 7.85, SD = 2.41) participated in the study. Data for two additional children were excluded due to the lack of cooperation with the testing procedures (n = 1) or insufficient number of artifact-free trials (n = 1). Typically developing status was verified by Peabody Picture Vocabulary Test-IV (PPVT-IV, Dunn & Dunn, 2007), and all children scored within the average to superior range (M = 137.03, SD = 32.77). The choice of this particular assessment of cognitive function was due to the design of a larger ongoing study that involves children with developmental disabilities for whom the PPVT is the most commonly used standardized assessment because it does not require a verbal or fine-motor response. All children had normal or corrected-to-normal vision and hearing. Three children were left-handed, the rest were right-handed (M = 0.66, SD = 0.63) as determined by Edinburgh Handedness Inventory (Oldfield, 1971).

Parents/guardians of the participants provided written informed consent, and all participants provided their assent. The study was conducted with approval from the university Institutional Review Board.