Research in Developmental Disabilities 45–46 (2015) 284–299

Contents lists available at ScienceDirect

Research in Developmental Disabilities

The effect of spatio-temporal distance between visual stimuli on information processing in children with Specific Language Impairment

Marco Dispaldro [a,*], Nicola Corradi [b]

[a] Dipartimento di Psicologia dello Sviluppo e della Socializzazione, Università di Padova, Italy
[b] Dipartimento di Psicologia Generale, Università di Padova, Italy

ARTICLE INFO

Article history:
Received 22 January 2015
Received in revised form 16 June 2015
Accepted 14 July 2015
Available online 13 August 2015

Keywords:
Specific Language Impairment
Selective attention
Information processing
Visual ability

ABSTRACT

The purpose of this study is to evaluate whether children with Specific Language Impairment (SLI) have a deficit in processing a sequence of two visual stimuli (S1 and S2) presented at different inter-stimulus intervals and in different spatial locations. In particular, the core of this study is to investigate whether S1 identification is disrupted due to a retroactive interference of S2.

To this aim, two experiments were planned in which children with SLI and children with typical development (TD), matched by age and non-verbal IQ, were compared (Experiment 1: SLI $n = 19$; TD $n = 19$; Experiment 2: SLI $n = 16$; TD $n = 16$).

Results show group differences in the ability to identify a single stimulus surrounded by flankers (Baseline level). Moreover, children with SLI show a stronger negative interference of S2, both for temporal and spatial modulation.

These results are discussed in the light of an attentional processing limitation in children with SLI.

1. Introduction

Language acquisition is a complex process, which is involved in a large part of the younger child's life (e.g., Tomasello, 2003). Usually, children at 5 years of age are able speakers. Unfortunately, some children are not able to acquire language in the same way as their same-age peers. This is the case of children with a Specific Language Impairment (SLI): these children show significant deficits in language abilities, without associated problems such as hearing impairment, neurological damage, or deficits in intelligence (e.g., Leonard, 2014). Epidemiological evidence indicates that SLI is present in approximately 5–7% of the preschool-age population (Tomblin et al., 1997). For many children with SLI, the disorder appears to have a genetic base; twin studies show that the concordance rates for children with SLI and their identical twins are substantially higher than those seen for children with SLI and their same-sex dizygotic twins (Bishop, North, & Donlan, 1995).

The linguistic phenotype seen in these children is not uniform. Different areas within language tend to be more adversely affected than other areas; however, the hallmark of SLI seems to be problems in the morpho-syntax area (Leonard, 2014).

* Corresponding author at: Dipartimento di Psicologia dello Sviluppo e Socializzazione, Università di Padova, Via Venezia, 8, Padova 35131, Italy.
E-mail address: marco.dispaldro@unipd.it (M. Dispaldro).

http://dx.doi.org/10.1016/j.ridd.2015.07.008
0891-4222/

Although language impairment is the most evident phenomenon, at present it is well known that children with SLI also have problems which are not confined to language: for example, these children show problems with sensory-motor abilities (Adi-Japha, Strulovich-Schwartz, & Julius, 2011; Finlay & McPhillips, 2013), with the manipulation of mental images (Guarnera, Commodari, & Peluso, 2013; Johnston & Weismer, 1983) or in musical and rhythmical processing (Przybylski et al., 2013).

The fact that children with SLI show deficits in both linguistic and non-linguistic domains (such as visual and auditory domains) allows us to assume that the nature of this disability is independent of language itself and, as a consequence, it is not possible to explain this disability assuming a specific-domain point of view (e.g., Chomsky, 1993). On the contrary, General Processing Limitation (e.g., Leonard et al., 2007) is one hypothesis that may account for the general impairment of these children. According to this approach, the phenotype shown in children with SLI is due to the fact that they have insufficient processing resources. Processing resources determine how much work can be done within a given time period; as a consequence, insufficient resources do not allow for correct information processing with both linguistic and non-linguistic stimulus. In characterizing children with SLI, limitations with processing resources have been identified in terms of 'speed' and 'capacity'. Speed of processing is a measurement of cognitive efficiency; it involves the ability to automatically and fluently perform cognitive tasks. Kail (1994) showed that children with SLI are slower information processors than normally developing children in both linguistic and non-linguistic tasks (see also, Windsor, Milbrath, Carney, & Rakowski, 2001; Windsor, Kohnert, Loxtercamp, & Kan, 2008). Limited capacity is also referred to as a restricted Working Memory (WM). Working Memory is traditionally considered to be the capacity to handle current demands to maintain and manipulate information, both presently incoming and previously stored. It is well known that children with SLI show restricted or inefficient WM ability with respect to typical same aged-peers both in visual-spatial and phonological domains (e.g., Marton & Schwartz, 2003; Vugs, Cuperus, Hendriks, & Verhoeven, 2013).

Recent research has begun to focus on the role of attention in SLI partly because attention seems to be a critical component of WM (e.g., Cowan, 1995; Gazzaley & Nobre, 2012). For example, in a study employing fMRI, Ellis Weismer, Plante, Jones, and Tomblin (2005) found that children with SLI differed from typical developing (TD) peers in the fronto-parietal regions associated with both attention and Schul, Stiles, Wulfeck, and Townsend (2004) found that children with SLI were slower in a visual spatial orientation task than a group of TD children matched for age. Finally, children with SLI were less accurate than age controls on a sustained attention visual and auditory task (Finneran, Francis, & Leonard, 2009; Montgomery, 2008).

In particular, selective attention seems to be strongly involved in language processing: Selective attention is the ability to focus our cognitive resources on information relevant to our goals (Gazzaley & Nobre, 2012). Despite the great amount of information flooding the scenes, we are able to focus our cognitive resources on one item and to process the relevant information. The link between selective attention and oral language has been explored in a series of Evented-Related Potential (ERP) studies in which participants listened to sentences. ERPs were then recorded during word-initial as compared to word-medial syllables within the sentences (for a review about selective attention and language, reading or mathematical abilities see Stevens & Bavelier, 2012). Adults and children with typical language showed a larger negativity beginning around 100 ms (N1) after the onset of word-initial (N1 is considered the first electrophysiological response of selective attention) compared to word-medial syllables, suggesting that when processing language, listeners selectively direct attention towards the beginning of the target (Astheimer & Sanders, 2012; Sanders & Neville, 2003; Sanders, Newport, & Neville, 2002). Stevens, Sanders, and Neville (2006) found that children with SLI showed no evidence of neural modulation in N1 suggesting that these children have deficits in the neural mechanisms of attention.

As previously mentioned, selective attention is the ability to direct cognitive resources to information relevant to the goal. When two stimuli are present, the selective attentional mechanism has to modulate the amount of cognitive resources that any stimuli can receive: It is well known that when both target and distractor-stimulus are presented, they compete for processing resources because the detection of the competitor-stimulus draws resources away from the target-stimulus (and vice versa) (Enns & Di Lollo, 2000; Keysers & Perrett, 2002); thus, we need to engage attention towards the relevant stimulus to prevent the interference of the distractor. The interference of distractors is proportional to their physical similarity to the targets (e.g., Hartley & Moore, 2002), their temporal distance from the targets (e.g., Potter, Staub, & O'Connor, 2002; Visser, Boden, & Giaschi, 2004) and/or their spatial location in the visual field (e.g., Carrasco, 2011; Fan, McCandliss, Sommer, Raz, & Posner, 2002).

With regard to temporal modulation, according to Sluggish Attentional Shifting (Hari & Renvall, 2001), if individuals are slower in directing cognitive resources towards the target, then it is unlikely that they will be able to perform a task in which a rapid stimuli sequence is involved. This is because their impaired automatic selective attentional system cannot direct cognitive resources from one item fast enough to move to the next. If attentional engagement/disengagement towards stimuli is not successfully completed in time, then the target's identification could be impaired and, as a consequence, information processing could be disrupted. Several decades ago Tallal (1980), Tallal and Piercy (1973a,b, 1974, 1975) and Tallal, Miller, and Fitch (1993) showed that children with language impairment were disrupted in detecting a series of brief auditory stimuli (linguistic and non-linguistic) when the inter-stimulus interval (ISI, the amount of time separating two ore more stimuli) was brief (e.g., 300 ms); on the contrary, no difficulties were found when the inter-stimulus interval was longer. Deficits in visual processing have been documented since the work of Tallal, Stark, Kallman, and Mellits (1981); these investigators found that children with SLI had difficulties, in relation to same age peers, in discriminating a sequence of brief letter-like visual forms. More recently, it has been shown that preschool children and adolescents with SLI have an impairment in temporal engaging and disengaging visual attention in a brief inter-stimuli interval with respect to their