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Cross-modal contextual coherence of information integration in people with Williams syndrome

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ABSTRACT

This study aimed to explore the generalization of contextual integration from within-modality (visual–visual) to cross-modal (visual–auditory) processing in people with Williams syndrome (WS), and to clarify whether the concreteness or social relatedness of stimuli contributed to contextual coherence using pictures. Contextual coherence was evaluated in accordance with context-appropriateness between visual backgrounds and auditory targets. The ability to judge appropriateness was defined as contextual integration ability, which leads to contextual coherence. The congruent conditions (e.g., a swimming pool vs. swimming goggles) and incongruent conditions (e.g., a movie theater vs. a hot-pot) were presented to people with WS and to typical controls. The results revealed a congruency effect in people with WS similar to that found in the typical controls matched by mental age. The generalization of contextual integration ability across modalities was demonstrated by comparing the findings on cross-modal presentation with those obtained in a within-modality visual study of people with WS. It was further clarified that the social relatedness of stimuli, and not concreteness, led to contextual coherence among people with WS.

1. Introduction

Since Williams syndrome (WS) was first diagnosed in 1961 (Williams, Barrett-Boyes, & Lowe, 1961), this clinical group with genetic deficits on chromosome 7q11.23 has been demonstrated as having an asymmetrical cognitive profile that features relatively good language but poor visuospatial construction ability (Bellugi, Lichtenberger, Jones, Lai, & George, 2000; Brock, 2007; Mervis & John, 2010). A series of studies has reported on the linguistic performance of people with WS in tests of syntactic knowledge and their insensitivity to word frequency in terms of lexical-semantic knowledge (Bellugi et al., 2000), including the simultaneous association of primary and secondary meanings to homonyms (e.g., bank: money, river) (Rossen, Klima, Bellugi, Bihrle, & Jones, 1996) and their knowledge of categorization with low-frequency hyponyms (e.g., brontosaurus, commentator) to hypernyms (e.g., animal) (Wang & Bellugi, 1993). A similar development of taxonomic categories (e.g., mouse, hamster) and functional words (e.g., broom, floor) as typical controls was reported in people with WS (Tyler et al., 1997). However, recent studies have revealed a delay in the development of metonym comprehension and the atypical development of functional category knowledge in people with WS (Thomas et al., 2010; Van Herwegen, Dimitriou, & Rundblad, 2013).

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1.1. Superficial lexical semantics in people with WS

Van Herwegen and colleagues (2013) presented short stories to test WS individuals' comprehension of metonyms (object–user relationship: *the apron* represented *the cook* vs. synecdoche relationship: *the moustache* represented *the man with the moustache*, p. 1304) from a developmental perspective. In a comparison of the developmental trajectories of WS participants and typically developing (TD) controls, the WS participants failed to show increasing accuracy with age in understanding metonyms. Further analyses showed a slower developmental rate for object–user metonyms compared to synecdoche metonyms in the TD controls, but no such difference was observed in WS individuals. Moreover, the WS individuals showed developmental delay in the comprehension of metonyms compared to the TD group when their developmental trajectories were plotted against their scores on the British Picture Vocabulary Scales. When tested on comprehension of metaphors, unlike the TD controls, people with WS not only failed to show improvement with age but also exhibited lower accuracy overall. The TD controls showed significant developmental trajectories of metaphors against mental age, whereas this association was not found in people with WS, suggesting an atypical development in comprehending metaphors.

Another study investigated semantic knowledge of relational linguistic comprehension in people with WS (Thomas et al., 2010), concluding that they lacked abstract knowledge compared with a TD group. Two studies were conducted: concept comparison and categorization. In the comparison study, for example, the participants first listened to a sentence (*The moon is like*_____) and then chose a word similar to the target object (moon) to form a pair from the following categories: literal (star), perceptual (coin), functional (candle), or anomalous (shoe). The results revealed that although the TD group preferred the functional similarities (oven) over the perceptual features (orange) of targets (sun) with the increase of verbal mental age, people with WS failed to demonstrate a similar effect of age on functional responses. Moreover, people with WS exhibited a delayed onset in the development of perceptual words pairing with anomalous words. In the categorization study, for instance, the participants listened to a sentence (*The sun is the same kind of thing as*_____) and then had to make judgments of similarity between literal words (moon) compared with perceptual (orange), functional (oven), or anomalous (chair) words (literal objects were always the correct answers in the categorization task). The results showed a tendency by the TD controls to categorize the functional features as more similar to the targets compared with the literal relations, but this was not shared by the WS participants. In contrast, the WS participants exhibited faster development in their literal responses than did the TD group because of the shown steeper trajectory from comparisons. It was concluded that the clinical group had a superficial understanding of lexical semantics and tended to access words based on less abstract meanings.

The investigation of causal inference ability by comprehending homonyms in people with WS also demonstrated superficial understanding of lexical items or local focus in contextual integration (Hsu, 2013b). In Hsu's study, people with WS listened to short narratives with causes and consequences which embedded homonyms, and then they were required to answer a comprehension question by choosing a context-appropriate meaning from three options (two were related to homonyms): the figurative meaning, the literal meaning, unrelated meaning. To achieve successful causal inference, participants had to link causes and consequences by correctly understanding the meanings of homonyms and selecting the context-appropriate meaning of homonyms to reach central coherence in context. For instance, the homonym Er3 ('ear' in Chinese with tone level) Bian1 ('side') Feng1 ('wind') has a figurative meaning of *being inattentive to a suggestion or command* and a literal meaning of *a wind blowing past the ears*. This homonym was embedded in the narrative scenario with syllables shared by the homonym with the literal meaning and the unrelated meaning (e.g., Er3 "ear" and Feng1 "wind"), but not with the figurative meaning. The results showed that among the groups, the participants with WS chose a significantly lower percentage of figurative meanings, suggesting a delayed ability for causal inference in contextual integration. They showed a significantly higher percentage of literal meanings and unrelated meanings as correct answers than the typical controls, implying deviance in the contextual integration of central coherence. Overall, people with WS paid more attention to features in contextual integration.

1.2. Atypical semantic neurological processing in people with WS

Weak central coherence was further observed in neurological measurements in people with WS while integrating semantically associated words into a connected semantic network in a study on false memory (Hsu, Karmiloff-Smith, Tzeng, Tai, & Wang, 2007). Hsu et al. (2007) presented wordlists with semantically related lexical items that were associated with covert central themes to participants. For instance, *taking medicine* (chi1-yao4 in phonological translation with tone levels in Chinese), *hospital* (yi1-yuan4), *getting a cold* (gan3-mao4), *cough* (ke2-sou4), *fever* (fa1-shao1), *cancer* (ai2-zheng4) and others related to a central theme of *getting sick* (sheng1-bing4). The central themes in the wordlists were not overtly stated. After presentation, the participants were asked to make judgments about whether each of the presented words had been heard before in the recognition test, classified as either old items (previously presented associates), lures (semantically related non-presented theme words), or new words (semantically unrelated non-presented words). The results revealed no behavioral difference in recognition rate to lures between TD controls and WS individuals, suggesting normal-like semantic knowledge in constructing networks of associated lexical words. However, the neurological signatures of the lures were different. While the TD controls processed the lures as previously presented old items, the people with WS processed the same lures as unrelated new words. Both the lures and the new words were significantly different from the old items in terms of their average peak amplitudes in the participants with WS. This atypical neurological finding of lexical-semantic