Developmental trends of performance on the Wisconsin Card Sorting Test in Korean children

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Although the Wisconsin Card Sorting Test (WCST) has been widely used to evaluate the frontal lobe functioning, there is no published data on normal children in Korea which results in limitation of its clinical validity in children. The present study was conducted to investigate developmental trends of normal children's performance on the WCST. The computerized version of WCST (Heaton, 1991) was administered to 160 elementary school children aged 7 to 11 years. Their Full Scale IQs measured by the Korean version of WISC-R ranged from 80 to 138 (M=111.02, SD=11.77). Children did not differ in FSIQ, VIQ, and PIQ when compared based on age. However, very moderate correlations were found between FSIQ, VIQ, and PIQ scores and the scoring variables. Out of the 10 WCST scoring variables, 9 variables except Failure to Maintain Set showed age effect, but sex difference was not found in any variables. There was also no significant interaction effect between age and sex. Important differences in developmental trends were found among the 10 WCST scoring variables. The nature of these differences was effectively explained by the three factors. From the principal axis analysis with oblique rotation using the 10 WCST scoring variables, three factors with eigenvalue greater than 1 emerged, interpreted as conceptual formation (Factor I: accounted for 60.24% of variance), perseveration (Factor II: 18.52% of variance), and ability to sustain attention (Factor III: 12.12% of variance). The growth curves for the 5 scoring variables constituting Factor I (Total Number of Corrects, Nonperseverative Errors, Conceptual Level Responses, Number of Categories Completed, and Trials to Complete First Category) showed significant improvement from age 7 to 8, suggesting a developmental spurt during that period. By contrast, Perseveration Errors included in Factor II significantly decreased from age 9 to 11, while Failure to Maintain Set included in Factor III showed no age effect. These results suggest that the WCST performance requires multiple cognitive functioning with different developmental trends.

Keywords: WCST, normal children, developmental trend, cognitive functioning.

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The Wisconsin Card Sorting Test (WCST; Grant & Berg, 1948), a frequently administered neuropsychological test, was developed to assess abstraction ability. Although its validity was first established through lesion studies, more recently functional imaging data have been used to corroborate the brain-behavior relationship. During the 1960's and 1970's, lesion studies showed that the WCST was sensitive to frontal lobe functioning (Drewes, 1974; Milner, 1963; Robinson, Heaton, Lehann, & Stelson, 1980). During the 1980's and 1990's PET and SPEC imaging studies have confirmed the pivotal role of the frontal lobe in WCST performance by documenting activation primarily of dorsolateral prefrontal cortex during test completion (Marenco, Coppola, Daniel, Zigan, & Weinberger, 1993; Rezai, Andreasen, Alliger, Cohen, Swayne, & O'Leary, 1993; Rubin, Holm, Friberg, Videbech, Andersen, Bendsen, Stromso, Larsen, Lassen, & Hemningsen, 1991). Studies about the cognitive and developmental effects of early frontal lobe injury among children have also sparked considerable interest in the WCST as a potential measure of frontal lobe functioning among school-age children (Chelune, & Baer, 1986; Chelune & Thompson, 1987; Welsh, Pennington, & Groisser, 1991).

In this study we investigated normative development in the WCST performance of school-age children in order to tap the developmental course of frontal lobe functions. Myelination of the frontal lobe proceeds rapidly from the age 4 until about age 13 (Reines & Goldman, 1980). Case (1992) argued that between age of 5 and 10 years, a sequence takes place in children's behavior that indicates a fundamental reorganization of their attentional and executive processes which are correlated with physiological changes in the frontal lobe of children. On the standard test on concept acquisition (Gholson & Beilin, 1979; Stevenson, 1968) which makes requirements similar to those of the WCST, 6-year-olds were reported to use their ability to classify along various dimensions to aid them in their hypothesis about which card is correct. By the age of 8, children showed the ability to shift to a totally different dimension if the first dimension selected yield an inconsistent pattern or if the rule is changed.

In three studies with school aged children (Becker, Isaac, & Hynd, 1987; Passler, Isaac, & Hynd, 1985; Welsh, 1987), investigators observed age-dependent changes in children's performance and suggested that behaviors attributed to the prefrontal lobe reveal the emergence of at least three stages of skill integration and maturation with differing developmental trajectories: at age 6, 10, and during adolescence. Some of these developmental trends can be placed in the larger context of normal cognitive development: For instance, changes in prefrontal–like skills at age 6 is consistent with what has been referred to in the field of developmental psychology as the 5 to 7 year shift (White, 1970). In a variety of content domains, investigators have documented rapid advances in systematic problems solving during this period; these advances have been attributed to increase in logical thought (Piaget, 1954), working memory (Case, 1985), and selective attention (Miller & Weisse, 1981). Given the pattern of data that was reported in the foregoing research, frontal lobe function generates a wave-like rather than a linear change (Case, 1992) which is roughly correspond to those stage-like moves to a higher level of processing postulated by Piaget (Phillips, 1969); preoperational thinking (aged 2 to 4), concrete