Central Coherence and Theory of Mind in children and adolescents with Autism Spectrum Disorder

Sanne Vingerhoeds

ANR: 587450

Instructor: dr. A. M. Scheeren

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Tilburg University, The Netherlands

Abstract

Central coherence is defined as being able to connect different pieces of information into a meaningful whole. Earlier research suggests that children with autism spectrum disorder (ASD) have difficulty with this, suggesting they have a weak central coherence. This study examines whether there is a difference in central coherence between children with ASD and without ASD. Secondly, this study examines if a significant correlation is present between central coherence and advanced theory of mind. It is expected that a weak central coherence is correlated with a poor theory of mind. Central coherence and advanced theory of mind were tested in 93 participants with ASD and 33 without ASD using the Children Embedded Figures Test and advanced theory of mind tasks. Results found no significant evidence for a difference in central coherence between the groups. Within the group of participants with ASD, no correlation is found between central coherence and theory of mind. However, within the group of participants without ASD, it is found that weak central coherence correlates with better advanced theory of mind. In conclusion can be debated whether central coherence should be used as a way to diagnose ASD and if further research is necessary.

Keywords: Central Coherence, Theory of mind, Children Embedded Figures Test, Autism Spectrum Disorder

Introduction

Autism spectrum disorder (ASD) is firstly characterized by persistent deficits in social communication and interaction (American Psychiatric Association (APA), 2013). This characteristic includes problems with social initiation and response, problems with non-verbal communication and problems with the concept of social relationships. Examples that are given by the DSM (2013) are intrusive touching, impairments in social use of eye contact and being withdrawn. Secondly, ASD is characterized by restricted, repetitive patterns of behavior, interests or activities (APA, 2013). This includes, among others, stereotyped and repetitive speech, motor movements and use of objects and hyper-or hypo-reactivity to sensory input or unusual interest in sensory aspects of environment (APA, 2013). Examples for this last aspect are poking own eyes and unusual preoccupation with texture and touch. ASD has an early onset and is seen to be of chronic nature, but severity and the occurrence of different symptoms vary greatly among individuals.

Unusual interest in sensory aspects of the environment might be explained by individuals with ASD not being able to fully focus on the global picture. To be able to focus on that global picture it is important to be aware of, understand and relate to our surroundings (van der Hallen, Evers, Brewaeys, van den Noortgate, & Wagemans, 2015). If we want to understand a facial expression, we need to combine all different aspects that the face shows, to understand the global picture of the facial expression. Usually our mind connects the different pieces of information into one 'Gestalt' (van der Hallen, et al., 2015). It is seen as 'normal' to be able to combine the different pieces of information to a higher-level meaning. This means we usually see the world as a global whole, instead of detail by detail. This is called 'central coherence' (Frith & Happé, 1994). Another example for central coherence that Frith and Happé (1994) give, is the ability to recognise certain words in different contexts. Meet and meat are words that have a completely different meaning, but are pronounced

roughly the same way. Given the context of the sentence, we can identify which word is meant by the speaker. This would not work if we focus on each word of the sentence individually.

Frith and Happé (1994) mention the 'Weak Central Coherence' theory. This theory describes that individuals with ASD have more difficulty to combine different pieces of information into a meaningful whole than their typically developing peers. It also states that the local processing of children with ASD is enhanced, suggesting a weaker central coherence. Van Lang, Bouma, Sytema, Kraijer and Minderaa (2006) found similar results. Their study made use of the block design task and the child embedded figures test. They found that children with ASD performed better on both tests than their matched controls, indicating a weak central coherence. However, in their meta-analysis, Van der Hallen et al. (2015) found no significant evidence for the weak central coherence theory and they did not include the study conducted by Van Lang et al. (2006). The meta-analysis concludes that children with ASD require more time to process information into a meaningful whole, because they start with processing the details. This could suggest more optional global processing instead of mandatory, meaning children with ASD do not automatically start global processing, contrary to their TD peers. (van der Hallen et al., 2015). Even though this study did not show significant evidence for the weak central coherence theory, it does suggest differences in central coherence in children with ASD compared to children without ASD, which is in line with the theory.

Not only is central coherence an important aspect of ASD on its own, it has also been linked to a theory of mind deficit that is found in individuals with ASD (Jarrold, Butler, Cottington, & Jiminez 2000). Children with a weaker theory of mind have more difficulty in predicting someone's behavior and they have a tendency to not being able to relate to others (Morgan, Maybery, & Durkin, 2003). Development of theory of mind is different for every

individual with ASD. Some pass first-order tests, such as false-belief tests (Happé & Frith, 1996). In false-belief tests it is tested if a child understands that someone else can have a false belief about the reality. However, children with ASD all show severe difficulty in mind-reading tasks, second-order tests, setting them developmentally behind their peers without ASD (Morgan, Maybery, & Durkin, 2003). This deficit in mind-reading can cause children to not be able to relate to others, and Jarrold et al. (2000) suggest that central coherence plays a part in this. They found that when children excelled on the Embedded Figures Test, suggesting they have weak central coherence, they also performed poorly on theory of mind tasks. Pellicano (2010) found a similar result. This research found that central coherence longitudinally predicted success on theory of mind tasks. As stated before, a child with weak central coherence focuses on local cues, such as the eyes and mouth individually. Because of this the child cannot recognise the facial expressions and it is possible he or she misses a lot of non-verbal information. This can cause the child to not be able to relate to the other, suggesting a weaker theory of mind. Even though Jarrold et al., (2000) did not find a significant correlation between central coherence and theory of mind, their study suggests a clear link between performance on the embedded figures test and theory of mind tasks. They state that in contrary to popular belief, it might be weak central coherence that can, among others, cause a poorer theory of mind. Even when theory of mind is available in a child with ASD, weak central coherence can cause limited use of it (Jarrold et al., 2000). Further research is suggested, to get a clearer image of the link between central coherence and theory of mind.

However, the results that have previously been found are mostly about first-order false belief tasks and not about advanced theory of mind (Miller, 2009). Advanced theory of mind includes second-order reasoning: ‘a belief about someone else’s belief about something in the world’(Miller, 2009). It can among others be measured by second-order false belief tasks,

which include social stories. These social stories require second-order reasoning, which are beliefs about someone's thought and feelings, about someone's metal state (Scheeren, de Rosnay, Koot & Begeer, 2013). An example is about John and Mary who are buying ice cream in a park. Mary goes home to get money and the ice cream vendor tells John that he will move locations. John does not know that the vendor also meets Mary and tells her this. The participant is asked where John thinks that Mary thinks the vendor is. 'X falsely believes where Y is' (Perner & Wimmer, 1985). Beaumont and Sofronoff (2008) found that children with ASD have significantly poorer advanced theory of mind than their TD peers. However, Roeyers et al. (2001) found that there is no significant difference in advanced theory of mind between children with ASD and without ASD. Once again results show to be ambiguous, needing more research to make a clear statement. On top of that, little to no research explains the link between advanced theory of mind and central coherence, in contrary to first-order theory of mind tasks.

This shows the importance of understanding central coherence in individuals with ASD. Central coherence can be measured through the Children Embedded Figures Test. In this test children have to find a certain shape in a bigger, complex line drawing. Past results when using this test have found that children with ASD were faster in finding the small figure than their matched control group (Shah & Frith, 1983). However, as stated before, further research found the results to be ambiguous and could easily be misinterpreted (van der Hallen, Evers, Brewaeys, Noortgate van den, & Wagemans, 2015). Different results can be caused by having different groups of participants. For example Scherf, Behrmann, Kimchi, and Luna (2009) found age to have an important effect on central coherence. They state that older participants show better global processing, suggesting a late development of central coherence. Other studies did not find age differences and thus most results cannot be generalized to the entire population. Because previous research has such ambiguous results, it

suggests that central coherence is still a vague concept and there are no clear guidelines as to how to fix this (van der Hallen, Evers, Brewaeys, Noortgate van den, & Wagemans, 2015).

This research will focus on comparing the central coherence of children with ASD to children without ASD, using the Children's Embedded Figures Test (CEFT), in hope to get a clearer image of central coherence in the researches sample. Among others, Frith and Happé (1994) found in their research a significant result on the CEFT. They found that children with ASD performed better than children without ASD. Based on this the first hypothesis of this research is that children with ASD will significantly outperform children without ASD on the CEFT. It is expected that children with ASD have more correct answers on the CEFT and a faster response time. Jarrold et al. (2000) suggest a link between central coherence and theory of mind, but further research would be necessary. Therefore the second hypothesis will focus on whether there is a significant correlation between the two concepts. A negative correlation is expected between number of correct items on the CEFT and score on the advanced theory of mind tasks. This means that when children have more correct on the CEFT, suggesting a weak central coherence, they score low on the advanced theory of mind tasks, suggesting a limited theory of mind. It is also expected that a positive correlation shows between time on the CEFT and score on the advanced theory of mind tasks. When children are faster on the CEFT, suggesting a weak central coherence, they score low on the advanced theory of mind tasks.

Method

Participants

In total 214 participants with ASD were recruited. The age range of this sample is 6 years old to 20 years old (M = 13.48, SD = 3.07). In order to be included in the final analysis, children and adolescents had to have a verbal IQ of 70 or higher, and an ASD diagnosis

according to the DSM-IV. This diagnosis was based on examinations of multiple clinicians who included anamneses, heteroanamneses, psychiatric and neuropsychological examinations. For a matched control group, 73 participants were recruited, with an age range of 6 years old to 17 years old (M = 12.15, SD = 2.82) (Scheeren, de Rosnay, Koot & Begeer, 2013).

Some required data was excluded from this study because the verbal IQ was < 70 (n = 4), there was incomplete IQ assessment (n = 6) or because tests were incomplete or unreliable (n = 15). Some participants with ASD scored <70 on the Social Responsiveness Scale. The SRS indicates characteristics of ASD, and a score <70 indicates only few characteristics. These participants were also excluded (n = 52). Some SRS data was incomplete. Because these participants have a clinical diagnosis of ASD, they were included, to increase the statistical power (n = 45). In the control group there was also data excluded due to incomplete IQ assessment (n = 3), incomplete tests (n = 24) or a high score on the SRS (n = 4). Within this group, some SRS data was also incomplete. Because these participants do not have a clinical diagnosis of ASD, they are included (n = 17). After the exclusion, 93 participants with ASD remained (19 female, 74 male) and 33 participants without ASD (3 female, 30 male), as seen in table 1. Independent t-tests were used to determine whether the two groups were similar on background variables other than the ones used in the hypothesis. This included age, verbal IQ and gender. The children and adolescents with ASD were significantly older than their typically developing (TD) counterparts (M_{ASD} = 13.59, SD = 2.84; M_{TD} = 11.47, SD = 3.30; p = .001). The verbal IQ also differed significantly (M_{ASD} = 104.06, SD = 13.37; M_{TD} = 110.42, SD = 12.88; p = .019). Gender ratio (χ^2 (1, n = 126) = 1.46, p = .23, phi = .13) did not differ significantly.

Procedure

This study was part of a bigger study, conducted in 2009 at 'Vrije Universiteit' in Amsterdam. This study focused on social-emotional skills of children and adolescents with ASD. Via specialized schools for children with normal intelligence and ASD participants were recruited. The school where most participants were recruited is the 'Berg en Bosschool', which is located near Utrecht. Children and adolescents that participated in the control group were recruited via public primary and secondary schools (Scheeren, de Rosnay, Koot & Begeer, 2013).

Parents received informative letters and could give their consent for their child to participate. Children with the age of ≥12 also had to give consent themselves. Upon receiving this consent, the children were individually tested at their school. The total duration of the tests was 90 minutes, and included among others the Children Embedded Figures test and advanced theory of mind tasks. The interviews were videotaped and later they were transcribed by students. After a child participated, their parents received a questionnaire, which they completed online or on paper.

Measures

Advanced theory of mind. This concept was measured through five social stories, which were read out loud and followed by a question. This question was about the mental state of one of the characters in the story. The five stories were derived from Sullivan et al. (1994), Begeer et al. (2011) and Kaland et al. (2008) and contain the following aspects: second order false belief, emotional display rules, violation of social rues, double bluff and irony (Scheeren, Begeer & Koot, 2012). An example of a social story is where Johan makes a faux pas while talking to someone. A question that could be asked is 'How do you think Mrs. Smit is feeling when she hears what Johan tells her?' (Scheeren, Begeer & Koot, 2012). When a question is answered correctly, one point is added to the total score, ranging from 0 – 5. A low score would suggest a poor theory of mind. Interrater reliability was moderate to very

good, with kappa's ranging from 0.57 (story 4) to 1.00 (story 1) (Scheeren, Begeer & Koot, 2012).

Central coherence. This concept was measured with the Children Embedded Figures Test. During this test the child was presented two types of complex line drawings. Within these pictures they had to search for either a 'triangle' or a 'house' shape that was embedded in the global picture (Witkin, 1971). The children had 180 seconds to find the shape. The item was scored 'wrong' (=0) if they were unable to find the shape in the set amount of time. It was scored 'correct' (=1) if the shape was found within the set amount of time and that time was also noted. In total there were 25 items. For some items during this study the interviewer stopped timing too early, meaning that the participant did not get enough time to find the figure and therefore some data was deemed unreliable. The scores on the CEFT can range from 0 to 25. A higher score means more correct items, indicating a weak central coherence.

Statistical analysis

ANCOVA was used to compare the two groups on score and time on the CEFT and score on the advanced theory of mind tasks, while adding age and verbal IQ as covariates. The following assumptions have been checked: level of measurement, random sampling, independence of observations, normal distribution, homogeneity of variance, measurement of the covariate, reliability of the covariate, correlations among covariates, linearity and homogeneity of regression slopes. The assumption of random sampling was violated. The assumptions of homogeneity of regression slopes and linearity were violated for the covariate 'age'. Because of this the covariate 'age' was dropped for this analysis. Partial correlation was calculated to determine the correlation between score and time on the CEFT and score on the advanced theory of mind tasks, while controlling for age and verbal IQ. The analyses were conducted using IBM SPSS statistics 22.

Results

Central coherence

The first hypothesis is that children and adolescents with ASD outperform children and adolescents without ASD on the CEFT, suggesting that the first group has a higher number of correct answers. Table 2 shows the means and standard deviations for these groups on scores on the CEFT and advanced theory of mind tasks, controlled for verbal IQ. When conducting the ANCOVA with 'number of correct items on the CEFT' as dependent variable, the assumption of equal variances was violated as seen in the Levene's test ($F(1, 124) = 5.50$, $p = .021$). However, after calculating the F-ratio ($F = 3.65$) and looking at the critical F-value ($F_{crit} = 3.84$), it can be concluded that equal variances can be assumed and thus the results of the ANCOVA can be interpreted. Counter to what was found in earlier research, children and adolescents with ASD do not have significantly more correct answers than their matched control group on the CEFT ($F(1, 124) = 3.67$, $p = .057$, partial eta squared = .029). Consequently, TD children and adolescents did not have significantly more wrong answers than the ASD group ($F(1, 124) = 2.89$, $p = .092$, partial eta squared = .023). Noticeable is that both these constructs do show a trend in the way the hypothesis expected. Children with ASD were not significantly faster than children without ASD ($F(1,113) = .603$, $p = .439$, partial eta squared = .005). Very small effect sizes (partial eta squared) were found on all analyses, indicating that sample size does not matter in this analysis. Interesting to note is that children and adolescents with ASD have significantly more answers correct on the advanced theory of mind tasks while controlling for verbal IQ ($F(1, 124) = 12.76$, $p < .001$, partial eta squared = .150). Hypothesis 1 can be rejected.

Central coherence and advanced theory of mind

Hypothesis 2 predicted a negative correlation between number of correct scores on the CEFT and scores on the advanced theory of mind tasks. Each of these partial correlations are calculated while controlling for age and verbal IQ. When the partial correlations are calculated within the group of children with ASD, no significant partial correlation is found between number of correct on the CEFT and number of correct on theory of mind tasks (r = .03, p = .80). No significant correlation is found between time on the CEFT and score on theory of mind tasks within this group (r = .11, p = .33). The results within this group are not in line with the hypothesis. When the partial correlations are calculated within the group of children without ASD, a significant positive partial correlation is found between number of correct on the CEFT and score on the advanced theory of mind tasks (r = .50, p = .009). Within this group, no significant correlation is found between time on the CEFT and score on the theory of mind tasks (r = -.012, p = .95). The results within this groups are also notin line with the hypothesis. When a partial correlation is calculated for the participants of the two groups together, a positive partial correlation was found between number of correct on the CEFT and score on the theory of mind tasks (r = .19, p < .05), as seen in table 3. This suggests that when there is a higher score on the CEFT, indicating weak central coherence, there is also a higher score on the advanced theory of mind tasks, indicating a better theory of mind. It is possible that this effect is due to the big significant correlation that is shown within the group of children without ASD and the results of the two groups together will not be interpreted. There is no significant correlation found between time on the CEFT and score on the advanced theory of mind tasks (r = .05, p = .60). The second hypothesis can thus be rejected.

Discussion

This study firstly examined whether there is a difference in central coherence in children and adolescents with ASD and without ASD. Secondly, it was examined if a negative

correlation exists between the number of correct items on the CEFT and score on advanced theory of mind tasks. Results showed no difference in central coherence between the two groups. Consequently, a very small effect size was found, meaning that the results are probably not caused by group size. Results also show no correlation between central coherence and advanced theory of mind in children and adolescents with ASD. On the other hand, within the group of children without ASD a positive association was found. This correlation suggests that when children show weaker central coherence, they also show a better advanced theory of mind.

The first hypothesis stated that children with ASD have significantly more correct answers on the CEFT, indicating a weak central coherence. The hypothesis can be rejected based on the results that are stated above. This is in contrast with the results that Frith and Happé (1994) and Van Lang et al. (2006) found in their studies. They found that children with ASD performed significantly better on the CEFT, indicating a weak central coherence. As stated before, this study did not control for the covariate 'age', as the assumptions for the ANCOVA were not met. Scherf et al. (2009) found that older participants with ASD have a better central coherence. Possibly, a significant result would have been found if the group was split in different age categories. On the other hand, the results that are found in this study, are similar to the results that were found by Van der Hallen et al. (2015) in their meta-analysis. They reason that children with ASD have a more optional global processing instead of mandatory. They also state that it may take longer for children with ASD to find the pattern in the complex line drawing. However, this study did not find evidence to support that. The results show no difference in time on the CEFT between the two groups. A possible explanation is that the setting is not completely natural. The line drawing does not represent the reality very clearly, which might lead children with ASD to process it differently. Perhaps

if the setting was more ecologically valid and more equal groups in terms of age were formed, a significant result could have been found.

Another possible explanation for the results of the present study comes from Ropar and Mitchell (2001), who found that performance on the CEFT varies among different types of ASD. They found that children with Asperger's syndrome did not differ from their typically developing peers on performance on the CEFT. However, children that are elsewhere on the spectrum perform better on the CEFT than their TD peers. In this study, it is not monitored where on the spectrum the participants are. It is possible that when that is registered and accounted for, the results are different. However, it can be debated whether that is necessary, considering the changes that were made from the DSM-IV to the DSM-V. In the most recent version of the DSM, there are no longer different types of ASD. It is a big spectrum. In future research, severity of the ASD symptoms can be taken into account, instead of the different types.

A final possible explanation that will be discussed for this hypothesis is knowledge of the different tests. The group of children with ASD already have the diagnosis, which is obtained via clinical professionals. It is possible that during the diagnostic examination, the CEFT or advanced theory of mind tasks were used. Because of this, the child might be familiar with the test and knows what kind of answers he or she should give, based on the last time they took the test. Consequently, children without ASD might not be familiar at all with these test, which could lead to lower scores.

The second hypothesis stated a weak central coherence to go along with a poor advanced theory of mind. The results suggest no such correlation whereby the hypothesis can be rejected. This suggests that within this sample of children with ASD, central coherence and theory of mind are not correlated. This is supported by Jarrold et al. (2000), who also did not find a result. However, the study conducted by Jarrold et al. (2000) suggests a clear link

between the concepts, something that is not shown in the results of this study. On the other hand, the results of this study do show that weak central coherence correlates with better advanced theory of mind in typically developing children, which was unexpected and not in line with the expectations. This correlation in children without ASD is little to not discussed in any research. Because this aim of this study was to examine the correlation within the group of children with ASD, it might be interesting for future research to examine the correlation of central coherence and theory of mind in the general population, not only in the population that is known to have a disorder.

While calculating the correlations, age and verbal IQ were taken into account, meaning that they have little to no influence on the displayed results. Jarrold et al (2000) suggest that a third factor could influence the results, for example non-verbal IQ or motivation. Those factors other than age and verbal IQ could have had an influence on the results of this study as well. However, in order to rule out any possible third factor, a lot more should have been tested, something that is hard to do in a limited amount of time.

An implication for this study in the general practice could be that theory of mind and central coherence have to be viewed as separate concepts in intervention for ASD, as they do not correlate. Examination should not conclude one of the concepts to be weak just because the other concept is. The results of the first hypothesis could also show that central coherence is not at all a factor that is more prevalent in children and adolescents with ASD. This could mean that if the CEFT is used to diagnose ASD, this might not lead to a reliable diagnosis, or none at all. Instead, there should be a focus on other diagnostic instruments, that are known to be good indicators of ASD.

One of the limitations of this study is that during the first analysis, the covariate ‘age’ was not accounted for. Because some of the assumptions were not met, it was decided to leave ‘age’ out of the analysis. In retrospect, this may have influenced the results. Future

research should try to include groups that are more similar to one another, in both age and verbal IQ, but also in severity of the disorder. This research did not take that into account, which leads to another limitation. Scores on the SRS were recorded, and exceptionally low scores were deleted for the ASD group, but there was no distinction in severity for the analysis. Another limitation could be the sample size of this study, which is not exceptionally large with 126 participants. It could be possible that if a bigger sample size is used, different results would have shown. However, only small effect sizes were found, suggesting that sample size does not matter. Consequently, Van der Hallen et al. (2015) researched over a thousand participants in their meta-analysis, and their result was also not significant. On the other hand, a larger sample size does make the study more generalizable to the general population. If a future study is to be conducted, a larger sample size could be more beneficial for interpretation of the results.

Even though recommendations for future research have been mentioned, it can be debated whether further research for central coherence in ASD is useful. This study and many others have found no difference in central coherence between children with and without ASD. Especially considering the recent meta-analysis conducted by Van der Hallen et al. (2015), who also did not find a difference in central coherence between children with and without ASD, it can be debated whether there should be any further research for central coherence at all. Instead, it could be more beneficial to examine other diagnostic instruments for ASD, that are known to be a good indicator of ASD.

In conclusion can be stated that this study suggests no difference in central coherence between children and adolescent with ASD and without ASD. This study also suggests no correlation between central coherence and advanced theory of mind in children with ASD. Implications of this study could be interesting for diagnosis and intervention of ASD, suggesting that central coherence is not a good indicator of ASD. Central coherence proves to

be an ambiguous concept and it can be debated whether future research is necessary. After multiple studies and a meta-analysis found no difference in central coherence between children with and without ASD, it might be beneficial to focus research on other concepts that are known to be good indicators of ASD, instead of central coherence.

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Appendix

Table 1

Comparison of means between children with ASD and without ASD

Variable	ASD		TD	
	M	SD	M	SD
Age	13.59	2.84	11.47	3.30
SRS score	91.88	15.80	31.49	11.41
Verbal IQ	104.06	13.37	110.42	12.88

Table 2

Means and standard deviations of scores on the CEFT and theory of mind tasks, controlled for verbal IQ

Variable	ASD		TD		F	Partial Eta Squared
	M	SD	M	SD		
Correct on CEFT	21.01	3.62	19.70	4.82	3.69	.029
Wrong on CEFT	3.77	3.28	4.73	4.01	2.89	.023
Time on CEFT	8.73	2.67	8.92	3.05	.603	.005
Correct on Advanced ToM tasks	3.81	1.01	2.88	1.17	21.76***	.150

*** $p < 0.001$

Table 3

Pearson partial correlation matrix, controlled for age and verbal IQ

Variable	1	2	3
1. Correct on CEFT	1		
2. Time on CEFT	-.07	1	
3. Correct on advanced ToM tasks	.19*	.05	1

* $p < .05$

Table 4

Pearson partial correlation matrix for children with ASD, controlled for age and verbal IQ

Variable	1	2	3
1. Correct on CEFT	1		
2. Time on CEFT	-.17	1	
3. Correct on advanced ToM tasks	.027	.11	1

Table 5

Pearson partial correlation matrix for children without ASD, controlled for age and verbal IQ

Variable	1	2	3
1. Correct on CEFT	1		
2. Time on CEFT	.23	1	
3. Correct on advanced ToM tasks	.50**	-.012	1

** $p < .01$