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Alloway, T.P., McCallum, F., Alloway, R.G. et al. (1 more author) (2015) Liar, liar, working memory on fire: Investigating the role of working memory in childhood verbal deception. Journal of Experimental Child Psychology, 137. pp. 30-38. ISSN 0022-0965

https://doi.org/10.1016/j.jecp.2015.03.013

Liar, Liar, Working Memory on Fire: Investigating the Role of Working Memory in Childhood Verbal Deception

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Published in Journal of Experimental Child Psychology (in press)

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Abstract

The aim of the present study was to investigate the role of working memory in verbal deception in children. We presented six-to seven-year-olds with a temptation resistance paradigm—they played a trivia game and were then given an opportunity to peek at the final answers on the back of a card. Measures of both verbal and visuo-spatial working memory were included. The good liars performed better in the verbal working memory test in both processing and recall, compared to the bad liars. However, there was no difference in visuo-spatial working scores between good and bad liars. This pattern suggests that verbal working memory plays a role in processing and manipulating the multiple pieces of information involved in lie-telling.

Keywords: deception, lying, verbal working memory, visuo-spatial working memory, semantic leakage.

Introduction

Verbal deception, or lying behavior, is an important ability in a range of different contexts, from social interaction and politeness situations (Talwar, Murphy, & Lee, 2007), to court witness and legal proceedings (Lee, Cameron, Doucette, & Talwar, 2002). A commonly used paradigm to investigate verbal deception is the temptation resistance paradigm (Lewis et al., 1989; Polak & Harris, 1999). The researcher instructs the child not to look at a specific, and often desirable, object, such as a toy, placed behind the child's chair. The researcher then leaves the room for a brief period. The researcher returns to the room, and asks the child if they peeked at the toy. They then ask the child a series of follow-up questions, involving the identity and color of the toy that was placed behind them.

If the child peeks at the toy, their ability to feign ignorance when answering the follow-up questions is called *semantic leakage control* and it involves second-order belief understanding (Talwar, Gordon, & Lee, 2007). In order to skillfully avoid detection, the child has to first adopt the examiner's perspective. The child assumes that the examiner is unaware that they have looked at the toy when the examiner left the room. Consequently, the child surmises that the researcher expects them to have no knowledge of the correct answer to the follow-up questions about the toy's size and color. The child's ability to hide their transgressions by lying about the size and color of the toy demonstrates how well they are able to understand the researcher's perspective and create a statement to match that perspective.

It is well-established that verbal deception is evident in children as young as three years old (Chandler, Fritz, & Hala, 1989; Fu, Evans, & Lee, 2012; Lewis, Stanger, & Sullivan, 1989; also Lee & Evans, in press, for a review). Lying abilities improve with age (Talwar & Lee, 2002), with several researchers pointing to the development of false belief—

understanding another's perspective, as one explanation for this improvement (Chandler et al., 1989; Polak & Harris, 1999; Talwar, Gordon, Lee, 2007; Talwar & Lee, 2008).

Other executive function skills, such as working memory, may also play a role in verbal deception (Evans & Lee, 2011). Working memory is the ability to process multiple pieces of information, continually update memory contents with incoming stimuli, and recall the appropriate information (Baddeley, 1996; Cowan, 2006; Engle, Tuholski, Laughlin, & Conway, 1999; Lustig, May, & Hasher, 2001; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001). There is reason to predict that working memory is involved in lie-telling as it could be recruited to keep multiple pieces of information in mind, such as the researcher's perspective and the actual transgression that occurred. The child would also rely on working memory to update their responses with follow-up questions from the researcher, and shift between the researcher's perspective and the fabricated reality that they constructed in order to avoid detection.

To date, there have been a few studies that have examined the role of working memory in verbal deception. However, the results have been mixed. In a 2008 study, Talwar and Lee gave three- to eight-year-olds a memory game, where there were six boxes with stickers. The children had to select one box at a time to find the sticker and remove it. The boxes were scrambled after each turn. This game involved visuo-spatial memory as the child had to keep track of the boxes they had already selected in order to retrieve the remaining stickers. When Talwar and Lee looked at the children's responses in a temptation resistance paradigm task, they did not find any difference between the lie-tellers, confessors, and non-peekers. In contrast, Evans and Lee (2011) found that older children (8-16 years) with higher working memory scores, measured with backward digit recall, were better at semantic leakage control, or covering their tracks. One possible reason for the difference in findings could be due to the nature of the working memory tasks. When it comes to verbal deception, verbal working memory may play a more prominent role compared to visuo-spatial working memory. Thus, it is possible that Talwar & Lee (2008) did not find a significant difference in their groups because they used a visuo-spatial memory task. Age may also have played a role as Evans and Lee recruited an older sample than those who participated in Talwar and Lee's study. Research by Lewis and colleagues have found that there is a clear age advantage when it comes to verbal deception, possibly as a function of better language skills (Lewis et al., 1989; see also Evans & Lee, 2011).

The aim of the present study was to clarify the roles of verbal and visuo-spatial working memory in verbal deception using a temptation resistance paradigm. Children played a trivia game and were then given an opportunity to peek at the final answer, although they were told not to peek. This paradigm allowed us to examine the children's ability to control semantic leakage—their ability to maintain consistency in their responses while telling lies.

In order to extend the previous research that investigated the role of working memory, we included both verbal and visuo-spatial measures of working memory and calculated the processing and recall aspects of the tests. Most theoretical frameworks of working memory include both verbal and visuo-spatial components that are related, but have dissociable effects on other tasks (Alloway & Alloway, 2013; Alloway, Gathercole, & Pickering, 2006; Baddeley, 1996; Engle, Kane, & Tulhoski, 1999; Miyake et al., 2001). For example, verbal working memory is linked to language skills (Gathercole, Alloway, Willis, & Adams, 2004), while visuo-spatial working memory is associated with math performance (see Cowan & Alloway, 2008, for a review). Furthermore, some students can display strengths in one area and weaknessness in another (Alloway, Rajendran, & Archibald, 2009).

The inclusion of processing and recall scores from the working memory tasks allow us to investigate which aspects are associated with verbal deception (see Alloway & Alloway, 2013). One possiblity is that the processing aspect of working memory is controlled by a centralized component (i.e., the central executive or controlled attention) and so both verbal and visuo-spatial processing would be linked to lie-telling. In contrast, the recall aspect is thought to be supported by a domain-specific component (i.e., verbal or visuo-spatial stimuli), and it is possible that only verbal recall would be linked to verbal deception. Therfore we predict that children's verbal working memory will be related to their semantic leakage control, while children's visuo-spatial working memory will not.

In the present study, six- and seven-year-olds were recruited as previous research demonstrates that this age group has undergone the develpmental shift required to successfully tell lies, and manage semantic leakage. For example, Talwar and Lee (2002) found that three to five year olds would blurt out incriminating information that revealed their lies, such as the name of the toy that they denied playing with. In contrast, a greater proportion of the six and seven year olds were able to successfully avoid revealing such information.

Method

Participants

A total of 137 children were recruited from the equivalent of a second grade class from four British schools. However, two participants from the experimental condition were not included in the data analyses as they did not follow the instructions for the trivia game. In the experimental condition, there were 114 remaining children (55% boys), with a mean age of 6 years, 8 months (SD=6.57 months; range: 5 years, 10 months to 7 years, 9 months). In the control (permission) condition, there were 21 children (52% boys), with a mean age of 6 years, 9 months (SD=7 months; range 6 years, 0 months - 7 years, 8 months). The children were predominately Caucasian and from middle-income families.

Materials and Procedure

Temptation resistance paradigm: This paradigm required the children not to peek at an answer on the back of a card when left alone in a room (see Talwar et al., 2007). The children were tested in school and told that they were going to play a trivia game where they had to answer three multiple-choice questions. For each correct answer, the child received a token. They were told if they collected three tokens they would receive a prize. All questions were written on cards with four possible answers written on the front of the card. The correct answer was written on the reverse side of the card in different colors of ink with an unrelated picture below the answer. The question was read aloud to the child. After the child answered, they were shown the card so they could see the answer and picture.

In Question 1, they were asked: *What noise does a dog make?* (Choices: meow, quack, woof, or moo). The back of the card had the answer in red ink (C: *Woof*) with a picture of a car. Question 2 was: *What colour are bananas?* (Choices: blue, green, pink or yellow). The back of the card had the answer in blue ink (D: *Yellow*) with a picture of a boat. The final question was based on a ficticious cartoon character: *What is the name of the boy in the cartoon 'Spaceboy'?* (Choices: *A: Jim; B: Ben; C: Lee*, or *D: Tom*). After the researcher presented this question, she left the room and told the child not to peek at the answer written on the back of the card. The answer was written in green ink on the back of the card (*A: Jim)* with a picture of a cartoon monkey.

After one minute, the researcher returned and asked the child if they peeked at the answer (Peeking Question). Then they asked them the answer to the question about *Spaceboy* (Trivia Question). If they answered the Trivia Question correctly, they were then asked two follow up questions regarding the color of ink the answer was written in and the picture on the final answer card (Entrapment Questions). The researcher asked the child: 'Can you guess what color the answer is written in?' (color question) and 'Can you guess what picture is on the back?' (picture question). If the children had peeked, then they would know that the correct answer to these questions were: *green* for the color question and *monkey* for the picture question.

We also included a control (permission) condition that used the same questions and followed a similar procedure. The main difference was that the children were told that they could look at the card with the *Spaceboy* question once the researcher left the room. They were not informed that they would be asked about either the color or the picture shown on the back of the card. The control condition was included to establish that the children understood what was required of them in the temptation resistance paradigm and to show that they would indicate that they looked at the card if they peeked, as they were given permission to look. The inclusion of this group allowed for the comparison of lying behavior compared to the experimental group.

A video camera hidden in a small cardboard box constructed to fit the camera was used to record each session with the children in both the experimental and control conditions. The session was recorded so that the researchers could see if the children turned the card over and looked at the answer. The researcher was unaware whether the child peeked at the card when she returned to the room.

Using the videos, behaviors were subsequently coded for peeking behavior (did they peek – yes or no); and lying behavior (did they admit to peeking – yes or no). We also coded the answer given to the final question if they peeked (correct or incorrect) and the answers given to the entrapment questions (color and picture). Based on their responses, children in the control and experimental conditions who peeked were classified as a good liar (lied to both entrapment questions) or a bad liar (lied about one or none of the entrapment questions). Sixteen videos from the experimental condition (14%) were coded by two raters independently. Cohen's Kappa was 1.00 for all answers.

Working memory. All test trials began with two items, and increased by one item in each block, until the participant was unable to recall three correct trials at a particular block. There were four trials in each block and the number of correct trials was scored for each participant. The stimuli in both working memory tests were randomized so no stimulus sequence was repeated to avoid potential practice effects. The move forward and discontinue rules, as well as the scoring, were automated by the program. The researcher explained the task to the child and confirmed that they understood the task. The children also watched a computer-led demonstration, followed by a set of practice trials before beginning the test trials.

In Processing Letter Recall, children viewed a letter in red that stayed on the computer screen for one second. The red letter disappeared and a letter in black immediately appeared. Participants verified whether the black letter was the same as the red letter by clicking ‘Yes’ or ‘No’ on the screen (processing). They then had to verbally recall the red letters in the correct sequence (recall). The number of correct responses for both the processing and recall components was scored.

Visual working memory was tested using a shape recall test. Participants viewed a colored shape in a 4x4 grid. The shape and grid disappeared and another shape appeared in the center of the computer screen. They verified whether those two shapes were the same color and shape by clicking on a box marked either ‘Yes’ or ‘No’ on the screen (processing). Then they had to remember the location of the first shape on the 4x4 grid in the correct sequence (recall). The number of correct responses for both the processing and recall components was scored. The raw scores for recall were converted into standard scores based on a normative sample (M=100, SD=15).

Results

Working Memory Scores

We first looked at the working memory scores across both the control and experimental conditions. The relationships within domains are stronger than between domains: Verbal WM Recall and Processing (r=.82) and Visuo-spatial WM Recall and Processing (r=.90); compared with Verbal and Visuo-spatial WM Recall (r=.30) and Verbal and Visuo-spatial WM Processing (r=.35). Based on the high correlations between the verbal working memory components (Recall and Processing) and the visuo-spatial working memory components (Recall and Processing), we calculated a composite each for verbal and visuo-spatial working memory. The following analyses were conducted on the composite working memory scores.

Peeking Behavior

Only a quarter of the children in the experimental condition peeked at the back of the card when the researcher left the room (n=28; 24.5%). In contrast, the majority of the children in the control condition, who were given permission, peeked at the back of the card (n=17; 81%). A chi-square analysis confirmed that more children in the control condition peeked compared to those in the experimental condition, χ^2 (1)=26.47, p<.001.

<Table 1>

We next looked at the working memory scores as a function of peeking behavior in the experimental condition (Table 1). A 2x2 MANOVA was conducted on the working memory composites (verbal and visuo-spatial) as a function of Peeking (Yes/No) and Gender. The Hotelling's Trace statistic indicated no significant difference in working memory performance as a function of Peeking: F<1. There was also no effect of Gender, F(1,108)=2.53, p=.09; nor an interaction, F<1. As gender did not yield significant group differences, it was not included in subsequent analyses.

Lie-Telling Behavior

When children who peeked were asked if they had looked at the answer while the experimenter was gone, only one child in the experimental group admitted to peeking (<1%), compared to 53% (n=9) in the control group. A chi-square analysis confirmed that there was a significant difference in admission to peeking between the groups: χ^2 (1)=12.01, *p*<.001.

A 2x2 MANOVA was conducted on the working memory composites (verbal and visuo-spatial) as a function of Condition (Control vs Experimental) and Lie-Telling behavior (Admit or Deny peeking). The Hotelling's Trace statistic indicated no significant difference in working memory performance as a function of Lie-Telling behavior, $F<1$; nor of Condition, $F(2,37)=1.24$, $p=.30$; and the interaction was not significant, $F<1$.

Trivia Question

We next looked at the response to the Trivia Question (What is the name of the boy in the cartoon S*paceboy*? Jim, Ben, Lee, or Tom) for peekers in both the control and experimental conditions. In the control condition, 100% of those who peeked answered correctly; while in the experimental condition, 95% of those who peeked answered correctly. The child who answered the Trivia Question incorrectly was not used in the analyses, nor was the child who confessed to looking at the card (n=26 in the experimental condition). A chi-square analysis confirmed that these responses in the experimental condition were significantly better than a 25% guess rate based on four possible responses; χ^2 (1)=18.78, *p*<.001.

Entrapment Questions

<Table 2 here>

Finally, we looked specifically at the link between working memory and the nature of the lies the children told. We divided the children who peeked in the control and experimental conditions into two groups: those who peeked and lied about their answers to both entrapment questions (good liars) and those who peeked but lied about one or none of their answers to the entrapment questions (bad liars; Table 2).

A 2x2 MANOVA was conducted on the working memory composites (verbal and visuo-spatial) as a function of Condition (Control vs Experimental) and responses to the Entrapment Questions (Bad vs Good liars). The Hotelling's Trace statistic indicated a significant effect of Condition, $F(2,35)=3.45$, $p=.04$, $\eta^2_p=.17$; but not for responses to the Entrapment Questions, $F(2,35)=1.37$, $p=.27$. The interaction between responses to the Entrapment Questions and Condition was significant for Verbal working memory, $F(1,36)=4.01$, $p=.05$, $\eta^2_p=.10$; but not in Visuo-spatial working memory, $F(1,36)=1.27$, $p=.27$. Post-hoc analyses ($p<.05$) indicated that in the experimental condition only, the good liars had higher Verbal working memory compared to the bad liars. This finding fits the predicted pattern that children's verbal working memory will be related to their semantic leakage control, while children's visuo-spatial working memory will not.

Discussion

The key finding in the present study is related to the role of working memory in verbal deception. The good liars performed better in the verbal working memory test compared to the bad liars. This is in line with Evans and Lee (2011)'s work; they found that of the participants who lied about their behavior, those with better verbal working memory were more able to cover their tracks in their follow-up comments (see also Walczyk et al., 2003 for a model integrating the role of working memory in deception). The finding that verbal working memory is associated with good semantic leakage control, while visuo-spatial working memory is not, adds to the existing literature and suggests there is a dissociable effect in sophisticated lying. This pattern corresponds with theoretical views that working memory capacity appears to be supported by two separate pools of domain-specific resources for verbal and visuo-spatial information that includes both recall and processing components

(Alloway & Alloway, 2013; Jarvis & Gathercole, 2003; also Miyake et al., 2001). In the present study, it is possible that verbal working memory was associated with verbal deception because both tasks draw from the same cognitive resources. For example, brain imaging research on adult deceptive behavior has identified activation in the prefrontal cortex, the same regions of the brain that is activated during verbal working memory tasks (Christ, van Essen, Watson, Brubaker, & McDermott, 2009).

The present study also indicates that Verbal working memory played a key role in lie-telling. In order for children to avoid entrapment when asked questions about the color the answer was written in, or the picture on the back of the card, they had to keep the researcher's perspective in mind (false belief), as well as manipulate all the components of their lie. They had to use their verbal working memory to maintain their deception and avoid being caught. Some researchers suggest that a capacity-based explanation of working memory can account for its link to false belief tasks (Keenan, Olson, & Marini, 1998). As the number of items that children can remember and process increases across development, they are better able to juggle the multiple pieces of information necessary in a false belief task, as well as represent more complex social connections between these relationships. Keenan (1998) suggested that the increase in working memory capacity provides children the mental 'space' to communicate social concepts that they were previously unable to express, due to limited mental resources. This skill leads to fewer errors in predicting others' mental states, as they can perform online processing of social cues, rather than rely on heuristics.

Perspective taking is an important component in a false belief task and recent research also suggests that perspective taking is partially regulated by working memory. In a study with college students, Wardlow (2013) reported that higher working memory scores meant that indvidiuals had more cognitive resources to allocate towards infering perspective differences in their conversational partner and intergrating that information with their behavior to guide their language use. Working memory is especially critical when the information is considered as privledged ground (knowledge known by one conversational partner) rather than common ground (shared knolwedge), as the listener has to recruit these cognitive resources in order to consider what to divulge and what to keep hidden (see also Lin, Keysar, & Epley, 2010; for additional support for the role of working memory in perspective taking).

With respect to peeking behavior, it should be noted that working memory did not play a role in their decision to peek, as there was no difference in performance between the peekers and nonpeekers in the experimental group. This pattern reinforces the idea that working memory plays a role in processing multiple pieces of information involved in the actual lie, but not prior to engaging in lie-telling behavior. Future research could investigate the role of working memory in verbal deception across development, as working memory capacity increases throughout childhood (Alloway & Alloway, 2013; Alloway, Gathercole, & Pickering, 2006), but lie-telling rates decrease (Jensen, Arnett, Feldman, & Cauffman, 2004).

While the present findings add to the exisiting literature on verbal deception in childhood, one limitation was the low incidence of peeking rates in our British sample compared to previous studies. Only a quarter of those in the experimental condition peeked when the researcher left the room, while 81% of those in the control group (which was given permission to look) peeked.

Several factors could explain the low peeking rates. First, older children peek less than younger children (Evans, et al., 2011; Talwar et al., 2007). Thus a study focussing on 6- and 7-year-olds would not find the same rates of peeking compared to studies focussing on children from 3 years (e.g., Evans et al., 2011; Polak & Harris, 1999; Talwar & Lee, 2008, with peeking scores ranging from 50%-95%). Second, British children may be less likely to peek than North American children. For instance, while around 70% of North American 3-

year-olds peek on a classic temptation (Evans, et al., 2011; Lewis, et al., 1989), only 50% of British 3-year-olds peek on a similar paradigm (Polak & Harris, 1999). Thus our sample being both older and British could explain the low peeking rates.

One explanation for why there may be cultural differences is the language used in the current study. Specifically, the word "peeking" may have had negative connotations for the current British cohort and they may have felt guilty about doing so (see Bloom & German, 2000 for further discussion on the salience of false belief tasks). The British children may have thought that the researcher was deliberately trying to trick them and may have refrained from peeking as a result (see Wellman, Cross, & Watson, 2001). Support for this view comes from the finding that almost half of the control group lied about peeking, while in a previous study, none of the control group lied about peeking (Talwar et al., 2007). There is substantial evidence that school-aged children are able to distinguish between moral judgements (i.e., the difference between right and wrong) and social conventions (i.e., societal norms; see Turiel, 2006). It is possible that the British children in the present study viewed "peeking" as a moral issue, rather than a social convention, and as a result some of them refrained from peeking when presented with the opportunity. This suggestion is speculative and further research could investigate the motivations that drive verbal deception in children, particularly in different cultures (see Fu et al., 2012; Talwar, Lindsay, Bala, & Lee, 2002).

In summary, the present study sheds light on the role of working memory in deception. The data suggest that while verbal working memory predicts lie-telling skills in six-year-olds, visuo-spatial working memory does not.

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Table 1: Working memory scores of the sample (*n*=131).

	1	2	3	4
1. Verbal WM: Recall	1			
2. Verbal WM: Processing	.82*	1		
3. Visuo-spatial WM: Recall	.30*	.31*	1	
4. Visuo-spatial WM: Processing	.28*	.35*	.90*	1

Note: WM= Working Memory; *. Correlation is significant at the 0.01 level (2-tailed).

Table 2. Working Memory performance as a function of non-peekers and peekers in the experimental condition.

	Non-peekers	(*n*=87)	Peekers	(*n*=26)
Working Memory scores	Mean	SD	Mean	(SD)
Verbal WM: Recall	88.34	10.86	88.22	10.83
Verbal WM: Processing	10.36	10.27	8.89	4.99
Verbal WM: Composite	49.35	10.11	48.89	7.37
Visuo-spatial WM: Recall	91.72	12.61	91.44	13.74
Visuo-spatial WM: Processing	11.36	9.51	11.63	11.43s
Visuo-spatial WM: Composite	51.54	10.76	51.94	12.52

Note: *=standard scores (M=100, SD=15).

Table 3: Working Memory performance as a function of bad and good liars in the control and experimental conditions.

	Control				Experimental			
	Bad liars	(*n*=10)	Good liars	(*n*=4)	Bad liars	(*n*=14)	Good liars	(*n*=12)
Working Memory scores	Mean	SD	Mean	(SD)	Mean	SD	Mean	(SD)
Verbal WM: Recall	82.30	7.27	80	1.01	84.29	8.54	93.50	10.83
Verbal WM: Processing	6.40	4.65	4.50	1.73	7.29	3.60	11.50	5.05
Verbal WM: Composite	44.35	5.89	42.25	.87	45.79	6.05	52.50	7.34
Visuo-spatial WM: Recall	92.20	12.86	83.25	4.72	91.36	15.98	92.50	11.46
Visuo-spatial WM: Processing	14.40	14.93	5.75	2.63	11.43	14.23	12.67	7.73
Visuo-spatial WM: Composite	53.30	13.62	44.50	3.49	51.39	15.01	52.58	9.45

Note: *=standard scores (M=100, SD=15)