Published in final edited form as:

Cogn Emot. 2013 June ; 27(4): 696–706. doi:10.1080/02699931.2012.736366.

Early Adolescents Show Sustained Susceptibility to Cognitive Interference by Emotional Distractors

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Abstract

A child's ability to continuously pay attention to a cognitive task is often challenged by distracting events. Distraction is especially detrimental in a learning or classroom environment in which attended information is typically associated with establishing skills and knowledge. Here we report a study examining the effect of emotional distractors on performance in a subsequent visual lexical decision task in 11- to 13-year old students (n=30). Lexical decisions about neutral verbs and verb-like pseudowords (i.e., targets) were analyzed as a function of the preceding distractor type (pleasant, neutral, or unpleasant photos) and the picture-target stimulus onset asynchrony (SOA; 200 or 600 ms). Across distractor categories, emotionally arousing pictures prolonged decisions about word targets when compared to neutral pictures, irrespective of the SOA. The present results demonstrate that similar to adults, early adolescent students exhibit sustained susceptibility to cognitive interference by irrelevant emotional events.

Keywords

attention capture; emotional distraction; lexical decision

Adaptive behavior requires the maintenance of an attentional focus on a task set, while ignoring competing, task-irrelevant, stimuli. For children, the ability to resist distraction has often been noted anecdotally as well as in the research literature, as an important prerequisite of successful acquisition of academic competency (Stevens & Bavelier, 2012). In the visual domain, numerous studies in adults have shown that emotionally engaging words or pictures are particularly effective distractors (Ihssen & Keil, 2009; Müller, Andersen, & Keil, 2008). For instance, the latency of naming the ink color in which words are written is delayed for emotionally engaging, compared to neutral words (i.e., the emotional Stroop effect; Pratto & John, 1991). Emotional distraction has been shown to impair subsequent cognitive tasks across several hundreds of milliseconds of time (Müller et al., 2008), even when a masking stimulus separates the distractor from the task (Ihssen, Heim, & Keil, 2007).

Conceptually, these findings have been taken to indicate prioritized allocation of perceptual and attention resources to the processing of relevant information, e.g., stimuli related to threat and reward (Bradley, 2009). It has been suggested that these stimuli engage evolutionary old motivation networks in the brain (Davis, Walker, & Lee, 1997), capable of capturing and holding attention to facilitate behavior that is critical for survival, such as fight or flight when detecting threat (Keil et al., 2010). Under certain circumstances, such prioritization is at the cost of processing a secondary task stimulus. Calvo and Castillo (2005), for instance, simultaneously presented a threat and a neutral word (e.g., virus and clock; the distractors) 300 ms prior to a lexical decision task. In the task, adult participants were asked to judge whether a string of letters (either a valid neutral word or a nonsense string) denoted a word or a nonword. Lexical judgments were slower when aversive, compared to neutral, distractors appeared in the fovea of the observer. Emotional distraction, however, is not specific to threat stimuli. Ihssen et al. (2007) showed university students pleasant, unpleasant, and neutral pictures (the distractors) prior to a lexical decision task on neutral verbs vs. verb-like pseudowords (the targets). Regardless of semantic category (e.g., erotica vs. mutilation) and temporal distance to the verbal items (80, 200, or 440 ms), emotionally arousing images delayed word reaction times.

Developmentally, distraction by salient cues has been shown to strongly impair behavioral speed and accuracy in a competing, primary, task. This effect diminishes as age progresses from childhood to adolescence, which has been taken to reflect the growing ability to focus attention (e.g., Ridderinkhof & van der Stelt, 2000). In a typical study (Cowan, Naveh-Benjamin, Kilb, & Sauls, 2006), 8- to 12-year-old children, younger (college-aged) and older adults (65-85 years) responded to color changes of one square embedded in a multi-object visual array. Results revealed that children and older adults had more difficulty binding visual features to locations than had younger adults.

Taken together, the findings briefly reviewed above support the notion that the ability to protect the attended information against continued distraction (i) may show a developmental trajectory, and (ii) depends on the saliency of the distractor stimulus. This notion has been corroborated in a number of studies focusing on high-anxious children and their processing bias towards threat-related stimuli. For instance, using the emotional Stroop task – sensitive to interference by concurrent affective information on an irrelevant task dimension – anxious children exhibited a greater delay in color-naming latency for threat words than their non-anxious peers (Vasey & MacLeod, 2001). From a developmental perspective, Kindt and Van Den Hout (2001) suggested that the tendency to prioritize threat-related information is a typical feature that is present in younger childhood, but can be increasingly inhibited as a child grows into adolescence. Anxious individuals, on the other hand, may fail to learn this skill. For instance, Kindt, van den Hout, de Jong, and Hoekzema (2000) reported that a bias for threat cues (here: spider words) in the Stroop paradigm was present in both fearful and non-fearful 8-year olds. Around 11 years of age, however, the priority given to threat-related information was found to be decreased in the control group, only. It should be noted that interference is not a unitary process and emotional Stroop interference to concurrent content may tap into different mechanisms compared to the serial distraction paradigms used in the present report.

The studies reviewed above have supported the existence of cost effects associated with processing emotionally arousing distractors in children and adults. The goal of the present report is to provide a systematic quantitative analysis of the extent and timing of emotion interference in students in their early adolescent years. Specifically, we sought to explore in this age group if task-irrelevant emotional pictures capture cognitive resources that would be no longer available for efficient performance in a subsequent lexical decision task, as has been observed in adults. We employed affective pictures as distractors as they allowed us to

maximize differences in emotional intensity, rather than word or face stimuli (Ihssen et al., 2007). Lexical decision paradigms are often applied to assess reading and visual word recognition skills in both clinical and typically developing populations (e.g., de Jong et al., 2009; McCutchen, Logan, & Biangardi-Orpe, 2009). To decide whether a letter-string is a real word or a nonsense word represents a cognitive process of higher order, in which the visual input is matched against an internal representation (Binder et al., 2003). Computational models of reading processes suggest that familiar words have an entry in one's internal lexicon and thus can be accessed efficiently (e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). Such lexical entries contain links to specific information about semantic, orthographic, and phonological aspects of a word. Here, we used verbs as word stimuli along with verb-like pseudowords involving common letter combinations. With these provisions, lexical decisions are not solely made on the basis of orthographic or phonological information, but provoke a participant to access semantic codes in the internal lexicon (Binder et al., 2003). Verbs were used because they can be expected to have strong associations with action representations and other widely distributed networks in the brain (Pulvermüller, Lutzenberger, & Preissl, 1999), thus tapping into the higher semantic processes that we postulate to be occupied by the emotional distractors. They also tend to be high in terms of concreteness (Ballmer, 1986). Moreover, this selection facilitates a comparison with our earlier work on emotion-induced capture effects in adults, using also verbs in the relevant task (Ihssen et al., 2007).

Early secondary-level students tend to exhibit considerable degrees of word reading fluency, indicating stable representations in the orthographic lexicon (Landerl & Wimmer, 2008). Empirical evidence further suggests that reading fluency is positively related to semantic decoding skills (Lutz Klauda & Guthrie, 2008). Given the literature reviewed above, we hypothesized that students would show interference effects from emotionally arousing pictures, potentially slowing subsequent decisions about verbal items. Emotional distraction has been found to increase with the amount of higher-order semantic encoding required for lexical decisions (Ihssen et al., 2007), thus interference effects related to processing pleasant and unpleasant pictures are expected to be more pronounced for words than pseudowords. To the extent that emotional interference in children has similar temporal parameters as found in adults (Ihssen et al., 2007; Müller et al., 2008), we predicted that response time slowing following affectively arousing distractors (pleasant and unpleasant images) is temporally sustained, extending across distractor-target intervals.

Method

Participants

Thirty participants (17 girls) between the ages of 11 and 13 years ($M = 12.21$ years, $SD = 0.72$) volunteered in the present study. At the time of testing, children had completed fifth and sixth grades of regular secondary schools situated on the German side of Lake Constance, located in the federal-states of Bavaria and Baden-Württemberg. German was the primary language for each student. Children with a history of specific language impairment or reading disability, or suffering from any neurological disease (e.g., epilepsy, brain injury) or psychiatric condition (e.g., affective spectrum disorder) were not included in this study. Furthermore, participants did not take any psychoactive medication and had normal or corrected-to-normal vision.

Because we presented a subset of aversive pictures in the lexical decision task (see below), participants were invited to fill in a standardized state-trait anxiety inventory (Kinder-Angst-Test-II; Thurner & Tewes, 2000) prior to the experimental paradigm. The trait-anxiety scale prompted the child to affirm or negate 20 statements addressing how he or she generally feels (e.g., *I often feel anxious*). In the 12-item state scale, the child's yes/no ratings

pertained to a forthcoming stressful event (e.g., *I am worried about what will happen now.*). Results revealed that none of the children were assessed as above-average trait anxious or scored in the ranges of mild or severe state anxiety.

Participants were tested individually in a single session, either in a quiet room at the school or at the University of Konstanz following the same administration procedure. Including breaks, a typical session lasted 50 minutes with the experimental task taking up about 25 minutes. Written informed consent was obtained from the parents of the children prior to the study; children gave their verbal assent. Each participant received a gift voucher or equivalent financial bonus at the end of the session.

Stimuli and Experimental Design

Pictorial (distractor) stimuli, being emotional and neutral in content, were taken from a pre-experimental rating study, which used a paper-and-pencil version of the Self-Assessment Manikin (SAM; Bradley & Lang, 1994). A total of 282 children 10 to 14 years of age rated 255 pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005), the Graphics Suite CD (Micrografx Inc., Richardson, TX, USA/Corel Corporation, Ottawa, ON, Canada), the “Human Lives” and “Potted Plants” Image Dictionary CDs (ImageDJ Corporation, Taipei, Taiwan, R.O.C.), and various web sites on the dimensions of hedonic valence and emotional arousal. Whereas judgments of hedonic valence indicate whether a stimulus is perceived as pleasant, neutral, or unpleasant, judgments of arousal reflect the intensity of motivational activation (Bradley & Lang, 1994). The hedonic valence or pleasure dimension of the SAM ranges from a big smiling, happy manikin to a frowning, unhappy manikin. Words such as very happy, pleased, or good and very unhappy, sad, afraid, or bad were used to make the endpoints accessible to the children. A jumping, wide-eyed figure with bursts in its belly at one extreme and a calm, sleeping figure characterize the arousal dimension. Expressions such as excited, nervous, butterflies in one's tummy, active, or wide-awake and extremely calm, relaxed, bored or sleepy gave children an understanding of the extremes. The unlabeled dimensions include five manikins, each separated by a small box. Marks could be made on the figure or the box, resulting in a 9-point assessment scale per dimension. Participants were instructed to rate a given picture first on the pleasure dimension, and then with respect to its arousal. Practice on two sample pictures ensured that each child understood the assessment procedure (for using the SAM successfully in children see e.g., McManis, Bradley, Berg, Cuthbert, & Lang, 2001; Müller, Winter, Schürkens, Herpertz-Dahlmann, & Herpertz, 2004).

Based on these ratings, 90 pictures were selected: (i) 30 high arousing pleasant exemplars displaying, e.g., sports events and foods favored by children (arousal: $M = 5.90$, $SD = 1.14$; valence: $M = 7.02$, $SD = 0.62$); (ii) 30 low arousing neutral items depicting, e.g., office scenes or potted plants (arousal: $M = 2.16$, $SD = 0.23$; valence: $M = 5.31$, $SD = 0.44$); and (iii) 30 high-arousing unpleasant distractors showing animal carcass, dental examination and more (arousal: $M = 4.86$, $SD = 0.83$; valence: $M = 2.45$, $SD = 0.56$). Within each affective category, pairs of stimuli were selected representing equivalent content (e.g., two pictures showing sky-diving, two pictures showing injections). This resulted in two semantically congruent stimulus sets A and B, consisting each of 15 pleasant, 15 neutral, and 15 unpleasant pictures.

Verbal (target) stimuli comprised neutral German verbs (e.g., *einleiten* = to introduce; *schieben* = to push) and pronounceable pseudowords (e.g., *einzeuben*, *schleiten*). An initial pool of verbs was generated containing items drawn from prevailing fourth-grade reading books (typically intended for 9- and 10-year-old students) to maximize familiarity with the stimulus set. Subsequently, we obtained SAM ratings (see above) for 160 verbs from 180 children aged between 9 and 13 years and selected 90 exemplars with low arousal ($M =$

4.27, $SD = 0.56$) and neutral valence ($M = 5.57$, $SD = 0.38$) scores for the present study. Using this set, 90 pseudowords were generated by permuting syllables and letters within or between verb stimuli. Pseudowords and words were matched for item length, initial letters, prefixes, and suffixes. Receptive language ability is expected to vary within the present sample and may affect the ability to decode words and pseudowords. We did however not include a measure of receptive language skills here and thus cannot speak as to the range of this trait present in the sample of our within-subjects design.

Distractors and targets appeared centrally on a gray computer screen at an average distance of 70 cm from the observer. A script written using Presentation software (Neurobehavioral Systems, Inc., Albany, CA, USA) controlled stimulus presentation and response registration. Before starting the experiment, we let the children complete 10 practice trials, involving stimuli not used in the test trials, to demonstrate the procedure and make sure that all children understood the task correctly. Each trial began with a 14.5×20 cm picture appearing for 100 ms. Black-colored verbal targets occurred immediately after a blank interval of either 100 or 500 ms resulting in (picture-target) SOAs of 200 or 600 ms, respectively. Targets were presented in 36-point Times New Roman font using lower-case letters as is customary for verbs in the German language. Children were asked to decide as quickly and accurately as possible whether the target stimulus was a real word in German by pressing the left mouse button with their right index finger or a nonsense word by clicking the right button with their right middle finger. Button assignments were counterbalanced among participants. Presentation of the verbal stimulus was terminated by the child's response or no later than 2000 ms post-target onset. No feedback was provided. After an interval randomly varying between 2500 and 3500 ms and displaying a central fixation cross, the next trial started. Figure 1 depicts a schematic of an example trial.

Each of the 90 words and 90 pseudowords was presented once in random order equally often at either the 200- or 600-ms SOA, for a total of 180 trials. The experimental session was divided into two 90-trial blocks, allowing the child to take a short break. In the first block word targets were randomly combined with pictures from set A and pseudowords with those from set B (see above). The assignment of words/pseudowords to the picture sets was reversed in the second block. The order of set assignment was counterbalanced among participants.

Data Analysis

For each participant and Distractor $\times$ Target combination, mean reaction time and error rate were calculated. Reaction times were analyzed for correct responses occurring in a time segment of 200 to 2000 ms following target onset. Based on earlier work, we considered this cut-off range a valid characterization of the dependent variable under consideration (e.g., West, Stanovich, Feeman, & Cunningham, 1983; Luce, 1986; Ihssen et al., 2007). To counteract large interindividual variability, reaction time scores were transformed using the natural logarithm. Error rate was computed as the number of trials with misses, wrong responses, and reaction times shorter than 200 ms. Speed and accuracy data entered separate $2 \times 2 \times 3$ repeated measures analyses of variance (ANOVAs), crossing the within-subjects factors SOA (2 levels: 200 ms vs. 600 ms), Target Type (2 levels: word vs. pseudoword), and Distractor Category (3 levels: pleasant, neutral vs. unpleasant picture). Partial eta-squared ($\eta^2 P$) values were reported as a measure of effect size (Cohen, 1988). Where appropriate, contrast analyses were used to follow up significant ANOVA results. Because no irrelevant variables were included in the present statistics, we refrained from Bonferroni correction for multiple comparisons (Nakagawa, 2004). This approach was intended to result in a compromise between maintaining statistical power and avoiding the risk of Type II error inflation. For all analyses, effects were deemed significant when $p < .05$.

Results

The statistical results of the ANOVAs run on the speed and accuracy variables are summarized in Table 1. Analysis of lexical decision errors revealed that children performed the task with high accuracy. Error rates ($M \pm SEM$) were lower for words (1.07 ± 0.17) than pseudowords (2.16 ± 0.26 ; main effect of factor Target Type), but were neither sensitive to influences of SOA nor pictorial Distractor Category. Given the overall low error rates and the lack of significant interactions, it is unlikely that the results presented below reflect a speed/accuracy trade-off.

For the log-transformed reaction time data, the ANOVA showed significant main effects of factors SOA, Target Type, and Distractor Category ($M \pm SEM$ are indicated): Children were slower in making lexical decisions when the distractor-target SOA was 200 ms ($1089.76 \text{ ms} \pm 35.04$) compared to 600 ms ($1060.46 \text{ ms} \pm 34.55$). At the same time, decisions about pseudoword targets ($1171.02 \text{ ms} \pm 36.65$) took longer than decisions about word targets ($979.19 \text{ ms} \pm 34.91$). Lexical judgments were also modulated by the emotional content of the preceding distractor. As revealed by contrast analysis conducted to follow up the main effect of Distractor Category, response times to targets increased from both pleasant and neutral pictures ($1070.61 \text{ ms} \pm 35.00$ and $1058.70 \text{ ms} \pm 35.30$, respectively) to unpleasant distractor items ($1096.01 \text{ ms} \pm 34.59$), quadratic trend: $F(1,29) = 14.97, p < .001$.

The main effects of factors SOA, Target Type, and Distractor Category were qualified by two significant 2-way interactions: SOA interacted with Target Type, and Target Type interacted with Distractor Category. Focused contrasts on the SOA by Target Type interaction (see Figure 2) indicated a larger word advantage in the 600-ms SOA, $F(1,29) = 103.97, p < .001$, than in the 200-ms SOA condition, $F(1,29) = 73.65, p < .001$. Post-hoc inspection of the Target Type by Distractor Category interaction (see Figure 3) showed that only decisions about words were significantly affected by the emotional content of the preceding picture, resulting in a quadratic trend for valid verbs, $F(1,29) = 15.35, p < .001$. As revealed by planned contrasts, children took significantly longer for word decisions after viewing unpleasant pictures, compared to pleasant, $F(1,29) = 6.62, p < .016$, and neutral exemplars, $F(1,29) = 19.03, p < .001$. In addition, and consistent with the overall quadratic trend for responses to verbs, a marginally significant word reaction time difference evinced between the pleasant and neutral Distractor Category, $F(1,29) = 4.00, p < .055$. No difference was obtained for pseudoword targets.

Discussion

This study set out to examine effects of emotional attention capture on subsequent processing of words and pseudowords in early adolescent students. By manipulating the temporal interval between the emotional distractor and the verbal target, we were able to investigate the dynamics of emotional interference across several hundreds of milliseconds. Consistent with our predictions, the main findings were as follows: Emotionally arousing pictures (pleasant and unpleasant) impaired processing of word, but not pseudoword, targets, leading to response time delays in lexical decision up to about 50 ms. Furthermore, such interference effects emerged irrespective of SOA, showing reaction time slowing for targets presented 200 or 600 ms after the emotional picture. This mirrors the pattern observed in adults (Ihssen et al., 2007).

The students performed the lexical decision task with overall high accuracy, exhibiting slightly but significantly lower error rates for words than pseudowords. The word advantage is in line with the typical lexicality effect (e.g., Neiningen & Pulvermüller, 2003; Ihssen et al., 2007), which is also manifested in accelerated response times to the same stimuli. The

low error scores might be indicative of a ceiling effect making them less susceptible to be modulated by the other factors in the design. On the other hand, it also demonstrates that the difficulty level of the verbal items (see Stimuli and Experimental Design) did not put the children at disadvantage, compared to studies in adults. Taken together, this pattern of results does not suggest that the participants responded more quickly at the cost of committing more errors.

The current findings parallel previous work, which used the same paradigm in adults (Ihssen et al., 2007). In our study, the selective impairment of word versus pseudoword responses indicates that distraction by emotional information is particularly harmful for concurrent lexico-semantic analysis. As suggested by work examining the neural correlates of the present task (Ihssen et al., 2007), the specific effects of emotion on word responses are linked to inhibited activation of the anterior temporal lobe, which is involved in associative functions and the representation of semantic codes (Pobric, Jefferies, & Lambon Ralph, 2007). In accord with these findings, our data show that emotional stimuli are prioritized by early adolescent participants even at long distractor-target SOAs, exerting sustained inhibitory influences on the lexico-semantic networks underlying word targets.

A strong quadratic trend across SOAs showed that in our study both unpleasant and pleasant pictures delayed responses to words, relative to neutral distractors, even though the magnitude of interference was largest for unpleasant distractors. Individual testing suggested that the difference between pleasant and neutral distractors was only approaching significance, which is consistent with notions in the literature that attention capture effects for pleasant material are most pronounced for categories such as erotica or romance (Ihssen et al., 2007; Schupp et al., 2004), which we could not include in this study. Pictures were selected based on pilot rating studies in a large sample of children to ensure reliable appetitive or aversive responses. Considerations of participant protection and external validity prevented us from using romance, erotic, threat, and mutilation scenes often relied on in research with adults (Ihssen et al., 2007; Schupp et al., 2004). Because of the broad range of content categories included in the present picture set (i.e., food items, sports, family fun, disgusting objects, unpleasant animals, etc.) the observed profile of interference suggests that one factor determining attention capture is emotional intensity/arousal (Ihssen et al., 2007; Schimmack, 2005). Our finding of increased reaction time slowing after negative pictures corroborates previous work showing a special role for negative affect in attracting and holding attention, e.g., in the emotional Stroop task (Pratto & John, 1991). Specifically, negative information may lead to a general slowdown of processing, stopping on-going cognitive activity and causing disruption to a wide range in tasks (Algom, Chajut, & Lev, 2004).

One limitation of the present study is the lack of variations in the emotional category of the verbal target (neutral words and pseudowords). Is it possible that interference effects in the lexical decision task were confounded by matching versus non-matching affective congruency between distractor and target, i.e., responses were facilitated for (neutral) targets following neutral pictures? Given that invalid words are affectively neutral, an effect based on emotional priming should lead to parallel patterns for neutral words and pseudowords in the present task. In contrast to this prediction, we observed emotion-related reaction time differences solely for the valid items, which is more consistent with interference exerted by the emotional stimuli on semantic processing of the words. Further, affective congruency effects strongly depend on the nature of the target task, showing reliable modulations only for evaluative responses (Klauer & Musch, 2003). Finally, work using rapid serial visual presentation to study emotional attention capture has shown that distractor-target congruency plays a minor role for the degree of emotional interference (Ihssen & Keil, 2009).

Developmental studies of cognitive control during sequential cognitive processing have shown that sharing resources among subsequent distractors and targets undergoes pronounced changes between 6-7 and 10-11 years of age (Heim, Wirth, & Keil, 2011). Older children (ages 10-11) exhibit a performance profile often observed in adult participants: They are able to quickly allocate their attention to two salient targets in a row (i.e., optimized attentional capacity). This performance profile is however accompanied by reduced report rates when target and distractor events alternate rapidly (i.e., the costs of attentional control). By contrast, younger children tend to show growing accuracy impairment with increasing temporal proximity of the target items, but no additional cost effects in response to intermittent distractors. In a similar vein, an alternating sequence of emotional and task stimuli modulated the brain response to the emotional stimulus in older (7-10 years), but not younger (5-6 years of age) children (Dennis & Hajcak, 2009). Adult-like sensitivity to interference by salient information alternating with task-relevant stimuli may thus be a function that is present in preadolescence, reflecting development of cognitive control strategies and neuroanatomical maturation (Segalowitz, Santesso, & Jetha, 2010).

The present study in early adolescents also suggests an emotion-cognition interaction in which task-irrelevant affective information interferes with subsequent lexico-semantic analysis in a similar way as has been observed in adults (Ihssen et al., 2007). Semantic networks are thought to undergo a continuous change in connectivity during school years, as children are exposed to written language in the context of a variety of topics (McGregor, 2004). Further work may therefore examine the point in time at which emotional attention capture effects emerge during development. A substantial portion of the research literature in adults implies that a variety of cognitive functions are impaired by preceding affective distractors in the same fashion, showing speed and accuracy decreases with increasing emotional intensity of the distractor (Schmuck, 2005). Emotional cues, however, may also benefit perceptual processing (e.g., Phelps, Ling, & Carrasco, 2006). Future studies in children may systematically manipulate the nature of the primary task to examine the conditions under which emotion facilitation versus inhibition takes place.

Acknowledgments

This work was supported by grants from the German Research Foundation (Deutsche Forschungsgemeinschaft, HE 3500/1-1) to SH and the National Institute of Mental Health (R01 MH084932) to AK. We wish to thank Christina Cerisier for help in data acquisition. We were especially grateful to the children who gave time to participate in this research, as well as to the parents and teachers for their commitment.

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Figure 1.

Sequence of an example trial in the experimental task. Here, the distractor is a high-arousing pleasant picture and the target a pseudoword, appearing with a stimulus-onset asynchrony (SOA) of either 200 or 600 ms. Participants were instructed to decide as quickly and as accurately as possible whether the target was a real word or a nonsense word by clicking the appropriate mouse button. Each lexical item remained on the screen until the child responded, but no longer than 2000 ms post-target onset. After a variable intertrial interval of 2500 to 3500 ms and showing a fixation cross, the next sequence started.

Figure 2.

Reaction time data (in ms) as a function of stimulus-onset asynchrony (SOA) and target type. Mean values of 30 children are depicted. Vertical bars indicate standard errors of mean. The typical lexicality effect, i.e., faster response times to words than pseudowords, was more prominent when the temporal distance between a distractor and a target was 600, compared to 200 ms.

Figure 3.

Reaction time data (in ms) as a function of distractor category and target type. Mean values of 30 children are shown. Vertical bars represent standard errors of mean. Pleasant and unpleasant distractor images impaired decisions about word, but not pseudoword, targets.

Table 1

Results of $2 \times 2 \times 3$ repeated measures ANOVAs for error and log-transformed reaction time data in the experimental task (n=30)

Factor Effects	DF	F-, p-, η^2 P-values	
		Error	Reaction Time
SOA (200 ms, 600 ms)	1,29	= 0.77, < .387, = .03	= 13.25, < .002, = .31 *
Target (Word, Pseudoword)	1,29	= 19.39, < .001, = .40 *	= 96.96, < .001, = .77 *
Distractor (P, N, U) ^a	2,58	= 0.97, < .385, = .03	= 9.90, < .001, = .25 *
SOA $\times$ Target	1,29	= 1.09, < .307, = .04	= 4.58, < .041, = .14 *
SOA $\times$ Distractor	2,58	= 2.66, < .079, = .08	= 1.46, < .241, = .05
Target $\times$ Distractor	2,58	= 1.00, < .375, = .03	= 3.19, < .049, = .10 *
SOA $\times$ Target $\times$ Distractor	2,58	= 0.06, < .939, = .00	= 1.13, < .331, = .04

* significant at the 5% level.

^aP = pleasant, N = neutral, U = unpleasant picture.