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Does the Viewpoint Deviation Effect Diminish if Canonical Viewpoints are used for the Presentation of Dynamic Sequences?

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Abstract

Two studies examine the visual presentation of dynamic sequences. Experiment 1 tests if there are canonical viewpoints, that are especially appropriate for presentation. Participants agreed that viewpoints with 90 degree deviation between axis of sight and axis of main movement in the sequence are better than other viewpoints. Experiment 2 examines if these canonical viewpoints weaken the perspective deviation effect in a recognition task according to their postulated information richness. A perspective deviation effect was found both for canonical and less canonical views, even if it was weaker for the canonical views.

Viewpoint Deviation and Canonicality

This paper deals with questions concerning the cognitive representation of visually presented dynamic sequences, specially the role of viewpoint. A first experimental series (Garsoffky, Schwan & Hesse, 2002) showed that the viewpoint from which one sees a dynamic sequence becomes part of the cognitive representation of that sequence and therefore influences later memory retrieval processes. This viewpoint deviation effect appeared in three experiments examining recognition memory for visually presented dynamic sequences (Garsoffky et al., 2002) and comprises the stable result, that cuttings from sequences are best recognized if they are presented in a viewpoint most similar to the viewpoint from which participants before saw the whole sequence. This means the cognitive representation of dynamic sequences is not uncoupled from the viewpoint from which one primarily saw the specific sequence and therefore influences later memory retrieval processes. The question now is, if this viewpoint deviation effect holds for all kinds of viewpoints or if the use of special viewpoints may reduce this effect. The following studies therefore ask, if various viewpoints differ in their qualification to present a sequence – i.e. if there exist so called canonical viewpoints that could by now only be shown for static objects (e.g. Palmer, Rosch & Chase, 1981) (Experiment 1), and further it will be investigated, if these canonical viewpoints have an influence on the viewpoint deviation effect found by Garsoffky et al. (2002) (Experiment 2).

The concept of canonicality in connection with visual viewpoints was firstly empirically investigated and defined by Palmer et al. (1981). They discuss the idea of canonical viewpoints from an information-processing approach, a categorization perspective, in terms of phenomenology, and with regard to the concept of affordances (Gibson, 1982) and they conclude, that canonical viewpoints compared to other viewpoints contain more information as well as information of high salience, are the most typical viewpoints of an object, are those viewpoints from which an object is most perceivable, and are especially qualified to present the affordance structure of an object.

Empirically canonical viewpoints are defined e.g. by asking participants to imagine an object and then to describe the viewpoint from which the imagination took place, or participants were asked from which viewpoint they would make a photo of an object, or participants had to choose between photos with varying viewpoints which photo in their opinion presented the object best (Blanz, Tarr & Bülthoff, 1999; Palmer et al., 1981). Evidence for canonical viewpoints is stated if there is high inter- and intraindividual agreement.

At least for static objects some conclusions about the nature of canonicality can be made that do not mutual exclude each other. (i) Functionality and familiarity: Especially objects of everyday life we often see from a specific viewpoint that corresponds with the functionality of that object, i.e. when interacting with that object we see the object from a specific, i.e. canonical viewpoint that allows optimal interaction (Blanz et al., 1999). (ii) Information richness: In some studies canonical viewpoints were discovered even for abstract or nonsense objects – a fact that can not be explained by familiarity or functionality (Cutzu & Edelman, 1994; Edelman & Bülthoff, 1992; Perrett &

Harries, 1988). It was concluded that canonical viewpoints present more information and especially more salient information of an object than other, less canonical viewpoints. They present a high number of visible surfaces of an object, important parts of an object are not covered, and they are stable against small variations of the viewpoint, i.e. the informational advances of that viewpoint remain the same even if the viewpoint is changed slightly (for a comprehensive list see Blanz et al., 1999). (iii) Discriminability: Cutzu and Edelman (1994) concluded from their findings using abstract objects, that because of limited cognitive capacity for every specific object only the diagnostically valuable attributes are stored, that help to distinguish this object from other objects. This means that it varies with changing contexts or tasks, which viewpoint is more canonical than other viewpoints.

This paper investigates if the usage of such high informative viewpoints, that allow optimal discrimination, leads to a more viewpoint independent cognitive representation of visually presented dynamic sequences. I.e. the question is if so called canonical viewpoints help to recognize sequences better even if they are presented from new viewpoints.

Experiment 1

In the first study it has to be determined if there exist canonical viewpoints not only for static objects but also for dynamic sequences and how they can be defined. The study picks up one classical way to examine the canonicality of different visual viewpoints (Palmer et al., 1981) – namely rating measures, i.e. participants judge the goodness of various viewpoints for presenting the dynamic sequence.

For dynamic sequences, there often is one main direction of movement, and it is supposed, that viewpoints are the more appropriate to present the sequence the more they allow the observer to understand this movement. Moreover it is assumed, that viewpoints deliver the more information according to this movement the more orthogonal they are to the main movement direction of the dynamic sequence. This is argued because viewpoints with the axis of sight parallel to the main movement direction cause perspective shortenings. So it is hypothesized, that viewers prefer viewpoints that are as much as possible orthogonal to the direction of the main movement and that viewers rate viewpoints worse if these viewpoints are more parallel to the main movement direction.

Method

Participants Six male and ten female students, from the University of Tübingen participated in this experiment. They were paid for their participation.

Apparatus Experimental procedures were controlled by a Microsoft computer and realized by a html-program. Film clips were presented on a black background in the left and the right half of a color monitor.

Stimulus materials and design Eleven dynamic sequences were programmed using xyZET (Härtel & Lüdke, 2000), a simulation program to teach physics in school. Each dynamic sequence consisted of four spheres (balls) with different colors, sizes, starting positions and velocities. All balls moved on parallel laps towards a kind of blue goal at one end of the rectangular space. So the sequences were similar to a kind of race, with the exception that the balls did not start at the same line and that not all of them reached the goal within the duration of the sequence. Each sequence was filmed from 5 different viewpoints: All viewpoints had the same height but differed according to the horizontal amount of deviation between the axis of sight realized by the camera perspective and the axis of movement direction of the balls; this amount of deviation could be either 0˚ (i.e. parallelism), 22.5˚, 45˚, 67.5˚ or 90˚ (i.e. orthogonality); see Figure 1. This resulted in 55 film clips (11 sequences by 5 viewpoints); three of these sequences, i.e. 15 film clips, were used for training, eight sequences, i.e. 40 film clips, in the experimental test. This variation resulted in a design with the variable "canonicality of presentation" (0˚ / 22.5˚ / 45˚ / 67.5˚ / 90˚; within-subjects).

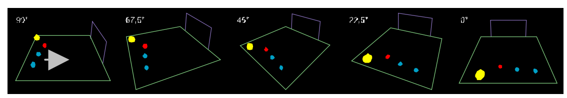


Figure 1: Visual presentations of the ball races used in experiment 1 with 0˚/22.5˚/45˚/67.5˚/90˚ amount of deviation between axis of ball movement (indicated by the little grey arrow) and axis of sight.

Procedure Participants were tested individually. The written instructions to the main part of the experiment – namely the rating of the film clip presentations at the computer - told them that they would see various dynamic sequences and that their task would be to rate the goodness of the viewpoint to present the dynamic sequence. It was explained, that the sequences were similar to races and that the relative positions of the objects to one another therefore is important when presenting the sequence. Further it was explained, that they always would see two film clips in succession presenting the same sequence but with different viewpoints and that they afterwards always should rate, which of the two film clips was the better presentation of that dynamic sequence by clicking with the mouse on one of two buttons (a button underneath the window of the film clip presented in the left half of the screen if they preferred this viewpoint or a button underneath the window of the film clip presented in the right half of the screen if they preferred that viewpoint). If participants had no more questions they were seated in front of the computer and a training phase started, which introduced some examples of the pair comparison task and trained to use the buttons. Data of the training phase were not analyzed.

When the film clip on the left side of the screen ended the last picture stayed in the window; after a short delay of one second the second film clip started on the right side of the screen. At the end of the film clip also the last picture stayed on the screen. Now the participant had to made his or her rating by clicking one of two buttons. Then a short text note followed on the screen, inviting participants to click another button when they wanted to start the presentation of the next two film clips.

The order of the dynamic sequences was randomized as well as the order of viewpoint combinations. For each dynamic sequence there were 5 different viewpoints and each viewpoint was paired two times with each other viewpoint of this sequence: one time presented on the left half of the screen (i.e. the film clip they saw firstly) and one time presented on the right half of the screen (i.e. the film clip they saw secondly). So subjects in the experimental phase saw eight sequences, each in form of 20 pairs of film clips. All together subjects had to make 160 pair decisions; each specific viewpoint could reach a maximum of 64 preferences.

Results

Ratings For each participant it was counted, how often he or she favored a certain viewpoint compared to another viewpoint (number of "preferences"). An ANOVA with repeated measurement was performed, including the variable "canonicality of presentation" (0˚, 22.5˚, 45˚, 67.5˚ or 90˚; within-subjects). There was a significant main effect for this variable, $\underline{F}$ (4, 60) = 8.457, $\underline{MSE}$ = 227.802, $\underline{p} < .01$ and also a significant linear contrast, $\underline{F}$ (1, 15) = 17.512, $\underline{MSE}$ = 397.233, $\underline{p} < .05$. The viewpoints were rated better, the more the axis of camera sight deviated from the axis of sequence movement (0˚: 21.375 preferences; 22.5˚: 25.688 preferences; 45˚: 27.688 preferences; 67.5˚: 36.125 preferences; 90˚: 49.125 preferences). Single comparisons according to Scheffé revealed significant differences between 90˚ on the one hand and 0˚, 22.5˚ or 45˚ on the other hand.

Discussion

The results allow three statements: (i) In presentations of dynamic sequences specific viewpoints are preferred against other viewpoints. That means there are "canonical viewpoints" not only for static object presentations but also for sequences presenting dynamic movement. (ii) More than that it can be defined, which viewpoints are preferred, namely as predicted those viewpoints whose axes of sight are orthogonal to the axis of main movement in the sequences. (iii) Further it could be shown that viewpoints are rated worse the more they differ from this best, i.e. canonical viewpoint. The significant linear trend is a hint that canonicality – measured by preference judgements - is not an all-or-none concept.

Experiment 2

Experiment 2 now examines if there is a relation between the canonicality of viewpoints found in experiment 1 and the viewpoint deviation effect (Garsoffky et al., 2002). A recognition task is used and it is investigated if a thoughtful choice of viewpoint when presenting a dynamic sequence the first time (i.e. canonical viewpoints in the learning phase) can lower the effect of viewpoint deviation during recognizing cutouts of dynamic sequences (in the test phase). The rational for this question is the idea, that canonical viewpoints are information richer (Blanz et al., 1999; Cutzu & Edelman, 1994; Palmer et al., 1981), and that therefore it should be easier to recognize cutouts from a sequence even from deviating viewpoints, because one has more information about the sequence.

Method

Participants Eight male and twelve female, from the University of Linz, Austria participated in this experiment. Because the task was very difficult we tried to motivate the participants by informing them that the best three participants receive a gift coupon for a local cinema.

Apparatus The experimental procedures were controlled by an Apple computer (Power Macintosh 8100/80AV) and programmed using PsyScope (Cohen, MacWhinney, Flatt & Provost, 1993). Film clips and video stills were presented on a black background in the middle of a color monitor. Reaction times were measured by the computer internal clock, thereby resulting in an unsystematic measurement inaccuracy of 17 msec.

Stimulus materials and design Sixteen dynamic sequences were programmed, now using 3D canvas (amabilis.com) because this software offered more different colors than the simulation software used in experiment 1. Each of the sequences consisted of four balls with different colors, that moved on a rectangular plane in a linear parallel manner. The balls either moved towards a kind of goal or away from this goal and had different starting points. Further the balls moved with different and individually varying speed, i.e. they accelerated and decelerated – so again some kind of "races" resulted. Acceleration and deceleration was necessary to prevent that viewers could predict the end of the race after seeing only the first parts of the sequences by simply extrapolating the starting speed and position of each ball. Each sequence was filmed with a desktop camera from two different viewpoints (all camera viewpoints were 20˚ above the horizontal plane) – with 90˚ deviation between axis of ball movement and axis of camera sight (hypothesized to be the more canonical viewpoint) and with 0˚ deviation between the two axes (hypothesized to be the less canonical viewpoint). In the 90˚ condition the balls moved in 50% of the cases from the left to the right side and in 50% of the cases from the right to the left side to preclude that the 90˚ viewpoint simply is better, because it realizes the familiar reading direction. Accordingly in the 0˚ condition, the balls moved in 50% of the cases towards the observer and in 50% of the cases away from the observer (see Figures 2 and 3).

For each sequence 5 points of time that were evenly distributed throughout the sequences were defined, to get enough measurement possibilities. For each of these points of time video stills for the recognition test phase were produced. These video stills had varying viewpoints on the sequence: All viewpoints had the same camera height (20° above the horizontal plane) but differed according to their horizontal deviation compared to the viewpoints in the film clips. This deviation could be 0°, 45° or 135°. Keep in mind that 0° does mean two different things for the film clips (learning phase) and the video stills (test phase): We speak of film clips with a 0° viewpoint, if there is no deviation between axis of ball movement and axis of sight. In contrast a video still with 0° is a video still the viewpoint of which does not deviate from the formerly presented viewpoint in the film clip – may this be a viewpoint with 0° or 90° deviation between axis of sight and axis of ball movement.

These variations resulted in a design with the variables "canonicality" (high / low; within-subjects), and "viewpoint deviation" (0° / 45° / 135° deviation between the viewpoints in the learning and the test phase; within-subjects).

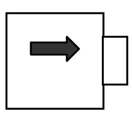
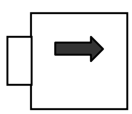
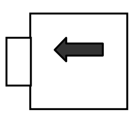
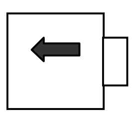
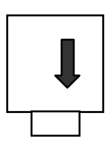
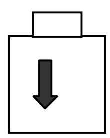
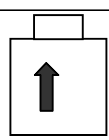
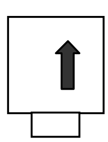
	balls moving towards the goal	balls moving away from the goal
90°; from left to right		
90°; from right to left		
0°; towards observer		
0°; away from observer		

Figure 2: Movement directions of the balls in experiment 2 towards / away from the goal, from the left to the right / from the right to the left, towards / away from the viewer, and with 0°/ 90° deviation between axis of ball movement and axis of sight.

Procedure Again all participants were tested individually and received written instructions to the main part of the experiment – namely a description of the kind of dynamic sequences and their recognition task. First they passed through a training phase, the data of which were not analyzed. The experimental phase encompassed 8 races, i.e. 8 blocks. Each block consisted of an initial learning phase followed by a test phase. In the learning phase participants saw a dynamic sequence twice from either a canonical (90°) or a less canonical (0°) viewpoint, i.e. they saw the same film clip two times in succession from the same viewpoint. One second later, they successively saw 15 video stills (five points of time of the sequence each presented from three different viewpoints) as well as 15 distractor video stills which used the same viewpoints but presented other sequences, i.e. the sequences showed the same balls (same colors) but the video stills stemmed from other races with the balls moving with other speeds. So to perform the recognition task participants had to decide, if a video still showed a moment of the race seen before in the film or another race by checking the relative positions of the balls to each other. The order of the video stills was randomized. Each video still stayed on the screen until the participant pressed one of two reaction keys (one marked with "j" for the german word "ja" which means "yes", and one marked with "n" for the german word "nein" which means "no"). After the participant had reacted to a video still there always was a short delay of one second before the next video still was presented. The order of blocks (i.e. the different sequences) was randomized and each sequence was presented in the learning phase to half of the participants from a canonical viewpoint and to the other half of participants from a less canonical viewpoint.

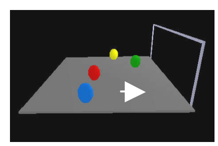
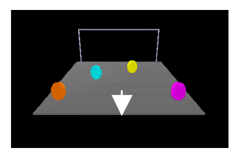
a)  b) 

Figure 3: Example pictures of the film clips used in experiment 2, arrows indicating direction of ball movement. a) shows balls moving towards the goal from the left to the right with 90° deviation between axis of ball movement and axis of sight. b) shows balls moving away from the goal towards the observer with 0° deviation between the two axes.

Results

Recognition accuracy For each participant his or her number of "hits" (the number of video stills correctly recognized as showing a moment from the ball sequence which he or she had previously seen) was determined. Across all participants and conditions a mean of 67.3 hits% resulted. Then an ANOVA with repeated measurement was performed, including the variables "canonicality" (high vs. low; within subjects), and "viewpoint deviation" (0°, 45° or 135°; within subjects). A significant main effect for "viewpoint deviation" was found ($F (2, 38) = 32.646$, $MSE = 0,006571$, $p < .01$) with 72.9 hits% at 0° viewpoint deviation between learning and test phase, 69.9 hits% at 45° viewpoint deviation and 59 hits% at 135° viewpoint deviation. Single comparisons according to Scheffé revealed significant differences between 0° and 135° viewpoint deviation as well as between 45° and 135° viewpoint deviation ($p < .01$). Accordingly, there was a significant linear effect of viewpoint deviation ($F (1, 19) = 52.432$, MSE = 0.007386, p < .01), also indicating that recognition accuracy becomes worse the more the viewpoint used in the test phase differs from the initially presented viewpoint in the learning phase. In addition, the interaction (see Figure 4) between "viewpoint deviation" and "canonicality" became significant (F (2, 38) = 9.364, MSE = 0.004185, p < .01). Single comparisons revealed significant differences between high and low canonical viewpoints in the learning phase only if there was 0˚ viewpoint deviation (p < .01); further if the viewpoint in the learning phase was low canonical, there were significant differences between 0˚ (77.8 hits%) and 45˚ (71.5 hits%) viewpoint deviation (p < .05) as well as between 45˚ and 135˚ (57.7 hits%) (p < .01); but if the viewpoint in the learning phase was high canonical, there was no significant difference between 0˚ (68 hits%) and 45˚ (68.3 hits%) deviation, but only between 45˚ and 135˚ (60.3 hits%) deviation (p < .01). There were no more significant effects in this analysis of variance.

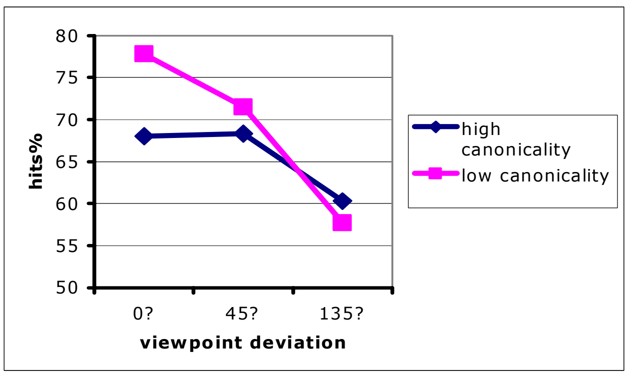


Figure 4: In experiment 2 for recognition accuracy there was a significant interaction between „viewpoint deviation“ and „canonicality“.

Recognition speed As a second dependent variable, reaction time was measured, i.e. the lapse of time from the beginning of each video still presentation until the participant pressed either the "j"- or the "n"-button. The following analysis only accounted for reaction times (RTs) to "hits" (i.e. correct "j"-reactions). Extreme RTs above 10 sec (i.e. more than 3 standard deviations above the overall mean) were excluded. This resulted in an exclusion of 1,16% of all RTs. To exclude outliers from analysis is a common method when dealing with reaction times (e.g. Cameron & Frieske, 1994; Diwadkar & McNamara, 1997; Eley, 1982; Hamm & McMullen, 1998; Lawson & Humphreys, 1996) because extremely slow responses indicate lapses of a participant´s attention on a particular trial. As the distribution of RTs was positively distorted, data were transformed by using natural logarithm, and analyzed in an ANOVA with the variables "canonicality" (high vs. low; within subjects), and "viewpoint deviation" (0°, 45° or 135°; within-subjects). For better vividness, the means reported in the text and figures are nontransformed RTs, despite the fact that the analysis of variance as well as the single comparisons were conducted using ln-transformed data. A significant effect was found for "viewpoint deviation" (F (2,38) = 12.194, MSE = 0.01284, p < .01). Applying single comparisons there were significant differences between 0° (2685 ms) and 45° (2944 ms) deviation (p < .01) as well as between 0° and 135° (3041 ms) deviation (p < .01). Accordingly also the linear trend for viewpoint deviation became significant (F (1, 19) = 16.387, MSE = 0.0179, p < .05). There were no more significant effects in this analysis of variance.

Discussion

In first line the results show once more (Garsoffky et al., 2002) a clear effect of viewpoint deviation: Recognition becomes worse the more the viewpoint from which one sees a cutout differs from the viewpoint from which one initially saw the sequence. This holds for recognition accuracy as well as for speed of recognition (see the two significant linear effects of viewpoint deviation). But the hypothesis that high canonical views in the learning phase weaken this viewpoint deviation effect receives only little support: On the one hand there is a significant interaction in recognition accuracy between canonicality and viewpoint deviation which shows that at least between 0° and 45° viewpoint deviation recognition accuracy does not become worse if in the learning phase a high canonical viewpoint is used. But on the other hand the use of a high canonical viewpoint in the learning phase does not weaken the viewpoint deviation effect between 45° and 135°. And at last there is no significant influence of canonicality on the viewpoint deviation effect for speed of recognition.

General Discussion

The results in the first place again support the stability and robustness of the viewpoint deviation effect for dynamic sequences (experiment 2): We used viewpoints that before (experiment 1) were rated as especially qualified to present critical aspects of visual dynamic sequences, namely the relative positions of the various balls to each other. I.e. these viewpoints were rated as being especially informative for this kind of dynamic event and therefore should allow to store in memory a maximum of discriminative information about the event. We hypothesized that if observers see dynamic sequences initially from these information rich "canonical" viewpoints, then the cognitive representations of the event should encompass more information and should therefore be more flexible if one has to rethink the event into other viewpoints – as demanded in the recognition task of experiment 2. But results show that the recognition performance still declines if the viewpoint presented during a later memory task differs from the viewpoint used in the initial learning phase, even if the observer initially saw the event from a canonical, information rich viewpoint. This means that the cognitive representation of a dynamic sequence still is viewpoint dependent, even if this viewpoint is especially information rich, i.e. delivers information about all or most important aspects of an event. This once more shows, that findings for static objects found by Biederman (Biederman, 1987; Biederman & Gerhardstein, 1993) cannot simply be assigned to dynamic sequences: According to the geon structural description theory (Biederman, 1987) the cognitive representations of static objects are viewpoint independent, as long as these objects are shown from viewpoints that encompass the discriminative details of these objects, i.e. the so called "geons", and their relative positions to each other. Our findings contradict the applicability of this idea for dynamic sequences: Even using high discriminative viewpoints does not lead to a viewpoint independent cognitive representation; in fact the rethinking in other viewpoints still is critical for recognition performance. So our present findings rather point out, that findings with static objects or static arrangements of objects e.g. from Diwadkar and McNamara (1997), Shepard and Metzler (1971) and Tarr (1995) are more appropriate to predict memory processes of observers watching dynamic sequences, namely the formation of a viewpoint dependent cognitive representation (see the two significant effects of viewpoint deviation in experiment 2 for recognition accuracy and speed of recognition) and the occurrence of mental rotation processes (see the significant linear trend of viewpoint deviation in experiment 2) if new viewpoints are brought into play.

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