Individual differences in the propensity to verbalize: The Internal Representations Questionnaire

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Abstract

Many people report experiencing their thoughts in the form of natural language, i.e., they experience 'inner speech'. At present, there exist few ways of quantifying this tendency, making it difficult to investigate whether the propensity to experience verbalize predicts objective cognitive function or whether it is merely epiphenomenal. We present a new instrument—The Internal Representation Questionnaire (IRQ)—for quantifying the subjective format of internal thoughts. The primary goal of the IRQ is to assess whether people vary in their stated use of visual and verbal strategies in their internal representations. Exploratory analyses revealed four factors: Propensity to form visual images, verbal images, a general mental manipulation factor, and an orthographic imagery factor. Here, we describe the properties of the IRQ and report an initial test of its predictive validity by relating it to a speeded picture/word verification task involving pictorial, written, and auditory verbal cues.

Keywords: Internal representations; inner voice; verbal representation; cognitive style; learning preference; thought; language.

Introduction

"Now that cognitive scientists know how to think about thinking, there is less of a temptation to equate it with language…" (Pinker, 1994, p. 59).

While the above quote conveys unwarranted optimism, it is true that modern cognitive scientists do not equate thinking with natural language. The fact remains, however, that the way many people frequently experience conscious thought has a certain linguistic property. But is this equally true for everyone? Do people vary in the degree to which they experience thought in the form of language? Is inner speech (for spoken language users) necessarily auditory in format (an inner voice) or do some people experience inner speech in a visual format (inner writing)? While there exist validated instruments for assessing some other aspects of internal experience, namely visual imagery (Blajenkova, Kozhevnikov, & Motes, 2006; Kirby, Moore, & Schofield, 1988; Marks, 1973), at present, there are few ways for quantifying the experience of inner language or speech (Brinthaupt, Hein, & Kramer, 2009; McCarthy-Jones & Fernyhough, 2011), though these instruments have been argue to have poor external validity (Uttl, Morin, & Hamper, 2011). In this work we seek to fill this gap by providing a new tool: the Internal Representation Questionnaire (IRQ). The goal of this questionnaire is twofold. First, we seek to quantify individual variability in how one individuals experience their thoughts, focusing on the *propensity to verbalize*. In order to relate this propensity to well-studied aspects of phenomenology, namely visual imagery, the questionnaire incorporates questions assessing visual imagery. Initial development identified a previously unstudied source of variability—a propensity to visualize orthography—which the IRQ also aims to assess. The second goal is to begin relating these individual differences—focusing on the propensity to verbalize—to objective cognitive function as. This is a first step toward understanding how people with high and low *propensity to verbalize* differ in cognitive performance, if indeed they do.

The intuition that some people are more "verbal" than others does not begin with us. Indeed, the idea of a 'visualizer–verbalizer' dimension has been described as one of the major cognitive styles (Riding, 2001). The intuition that some people think in more visual ways while others in more verbal ways has motivated the "learning styles" cottage industry, according to which preferences in representing information in more visual or verbal ways have consequences for how information should be presented to people in educational contexts, (for review see, Sternberg, Grigorenko, & Zhang, 2008). While evidence for such a link between individual differences and educational outcomes is lacking (Pashler et al., 2008) the existence of individual differences in the experienced format of conscious thought, and the extent to which these subjective differences are predictive of objective measures, are important and poorly understood.

Individual differences in the format of conscious experience have been studied most in the domain of visual imagery for over a century. In 1880, Francis Galton published the results of the first known investigation of individual differences in visual imagery (Galton, 1880). By his own admission, Galton had impoverished mental imagery and considered it inimical to abstract thought. And so it is perhaps of little surprise that the conclusion of his survey was that "the great majority of the men of science … protested that mental imagery was unknown to them, and they looked on me as fanciful and fantastic in supposing that the words 'mental imagery' really expressed what I believed everybody supposed them to mean" (Galton, 1880). More recent investigations found that scientists do not have reduced vividness of visual imagery (and indeed, it is a conclusion contradicted by Galton's own data). To date, there have been numerous studies of individual differences in visual imagery (Amedi, Malach, & Pascual-Leone, 2005; Cui, Jeter, Yang, Montague, & Eagleman, 2007; Hatakeyama, 1997; Keogh & Pearson, 2011; Marks, 1973; McKelvie, 1994; McKelvie & Demers, 1979). In a partial vindication of Galton's claims that visual imagery is not universal, a small percentage of people do seem to not experience visual imagery at all—a condition termed 'aphantasia' (Zeman, Dewar, & Sala, 2015), though at present there is little understanding of the effects of this condition on cognitive and perceptual function. The extent to which current instruments measure individual differences in a habitual approach is limited and not clearly distinguished from learning preference or ability (Sternberg & Zhang, 2001, Mayer and Massa, 2003).

Far less research focuses on the idea of inner speech in general. The Self Talk Scale (STS: Brinthaupt et al., 2009) includes concepts of 'self-talk' though does not explicitly distinguish between internal and vocalized experience. The Varieties of Inner Speech Questionnaire (VSIQ: McCarthy-Jones & Fernyhough, 2011) probes experience of inner speech, though with a focus on the possible association with psychopathology, the statements are in a context of self-appraisal e.g., "I hear my mother's voice criticizing me in my mind." Instruments such as the visual-verbal questionnaire (VVQ; Kirby et al., 1988) have also been used as a means of getting to this construct (Jonassen & Grabowski, 1993), but the verbal dimension of the VVQ contains a grab bag of language-related questions assessing, e.g., how much one likes to look up words in a dictionary, whether a person remembers the words to songs, and a preference for reading instructions rather than being shown how to do something. It is thus poorly suited for assessing a propensity for verbalization—the first aim of the present work. Do people vary in a preference to use verbal strategies in their internal representations, and does this relate to cognitive performance?

Constructing the IRQ

We constructed the questionnaire by following standard guidelines for designing psychometric scales (Clark & Watson, 1995; Simms, 2008). In the primary phase of scale construction, we created 82 question items which were designed to assess different aspects of representing internal thoughts e.g., visual, verbal, textual. We generated novel items designed to assess cognitive style specific to understanding modes of experiencing mental representations internally. Several visual items of the VVQ VVIQ, and object and spatial items from the Object-Spatial Imagery Questionnaire (OSIQ) were also included (Blajenkova et al., 2006; Kirby et al., 1988; Marks, 1973). The 82 questions were piloted on 180 students at the University of Wisconsin Madison. Items that did not correlate higher than .30, or correlated above .90 with other items were excluded or rephrased. Items were also assessed for poorly functioning items or gaps in content. A refined 60-item scale was then administered to adults on Amazon's Mechanical Turk. A total of 222 participants were retained. Participants were aged between 20 and 72 (123 male, 96 female , 3 categorized as other or preferred not to state, mean age 36 SD 11 years). Participants used a 5-point Likert scale to report the degree to which they agreed with each statement from 'Strongly Disagree' to 'Strongly Agree'. Participants were excluded if they incorrectly responded to any of three attention checks included in the study.

Exploratory Factor Analysis was conducted to assess the dimensionality of the scale. Four factors were retained in the model, selected based on the point of change on the scree plot. Items were subsequently dropped that had factor loadings less than .40, as well as any items that had factor loadings greater than .40 onto another factor. Items would also be excluded if analyses revealed that Cronbach's alpha would be increased by their exclusion. Homogeneity was also assessed through interitem correlations. If any correlation for an individual item was less than .3 with the sub-factor, the item would also be removed. A total of 37 items were retained. See Table 1 for example items.

Factor	Example item
Visual	I often enjoy the use of mental pictures to reminisce. I can close my eyes and easily picture a scene that I have experienced. *If I imagine my memories visually they are more often moving than static.*
Verbal	When I think about someone I know well, I instantly hear their voice in my mind. I think about problems in my mind in the form of a conversation with myself. *My memories often involve conversations I've had.*
Manipulation	I can easily imagine and mentally rotate three-dimensional geometric figures. I can easily choose to imagine this sentence in my mind pronounced unnaturally slowly. *I can easily imagine the sound of a trumpet getting louder.*
Text	I find it easy to decide if words rhyme by seeing their spelling in my mind's eye. When I hear someone talking, I see words written down in my mind. *I rehearse in my mind how someone might respond to a text message before I send it.*

Table 1 Example IRQ items with high loadings on the named factor. Lowest loading items are italicized.

Cronbach's alphas for the four subscales were .86 (Propensity to Visualize), .86 (Propensity to Verbalize), .72 (Mental Manipulation) and .79 (Propensity to Textualize).

The Propensity to Visualize factor included 10 items that described some aspect of visual/pictorial imagery when thinking and were not directly language based. The

Propensity to Verbalize factor contained 12 items relating to an experiencing thought in an inner voice of spoken language i.e., internally hearing words. Unlike the other factors that focus on mode of representation, The Mental Manipulation factor contained 8 items relating to the ability to vividly imagine a modification to an internal representation e.g., orientation or sensation quality. The Propensity to Textualize factor contained 7 items related to visualizing the written or textual form of words (a visual counterpart to the spoken representation of language observed in the Verbal factor).

The factor themes were named based on how the items clustered, and were not predefined. For a full list of the items see https://osf.io/8rdzh. Orthogonal rotation was carried out for the analysis due to sub factor correlations see Table 2.

	Visual	Verbal	Manipulation	Text
Visual				
Verbal	.47 **			
Manipulation	.42 **	.29**		
Text	.35 **	.38 **	.31**	

Table 2. Correlations between each of the four sub-factors in the IRQ.

The four factors identified by exploratory factor analysis were positively correlated with one another other. Contradicting a popular assumption, a propensity to verbalize was not inversely related to a propensity to visualize. For representation of the variability of scores reflecting individual differences in internal representations across each of the factors see Figure 1. Zero indicates least agreement and 5 indicates strongest agreement (accounting for reverse-coding of questions).

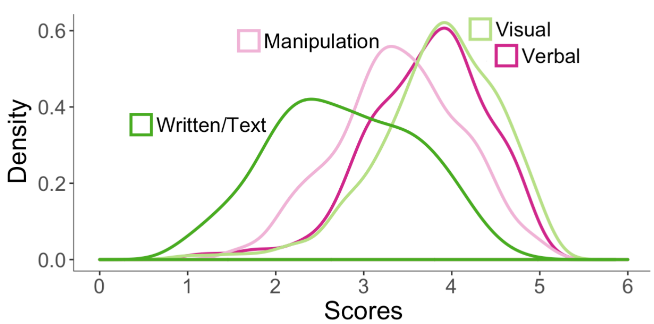

Figure 1Density plots for each of the IRQ Factor Scores.

To assess internal reliability, split-half analysis was conducted on odd and even questions within each factor. The split half correlation for the IRQ was .71. The reduced version of the questionnaire was then retested on a subset of the 222 participants on Mechanical Turk, of which 125 completed the questionnaire a second time from 65 to 74 days later. Test re-test reliability correlations for each of the 4 factors: were .78, .68, .65 and .64.

External validation of the IRQ

As an initial validation, we sought to examine whether a propensity to verbalize led people to a greater activation phonology from visual inputs as assessed by examining rhyme judgments (e.g., Langland-Hassan, Faries, Richardson, & Dietz, 2015). Participants took part in a cue-target verification a task in which cues and targets were presented in different formats and modalities. Participants had to indicate whether a word (spoken or written) or picture matched a subsequently presented word or picture. Non-match trials included cue-rhymes which were expected to slow down RTs to the extent that participants activated phonology of the cue stimulus.

Participants

We recruited 107 University of Wisconsin undergraduates to complete a speeded verification task followed by the IRQ. Participants were subsequently excluded if they failed any of the attention checks in the questionnaire, or made more than 10% errors in the experimental task. Twenty-three participants were excluded on this basis. Participants were aged between 17 and 23 (44 male, 40 female, M_{age}=19).

The verification task consisted of seeing/hearing a cue followed by target and responding match/mismatch depending on whether the cue matched the target. The cues and targets were spoken words, written words, and pictures of 36 familiar monosyllabic animals/artifacts (e.g., owl, beer, sock, shell). Participants were required to press a green button as quickly as possible if the two items matched e.g., cat and cat, and the red button if the items did not match e.g., cat and box. A buzzer sound would play for 1000 ms after an error. Two different exemplars were created of each word in each modality i.e., two different picture exemplars, two written exemplars (lower and upper case) and two spoken exemplars of each word from a single female speaker. The words were balanced in terms of scores of frequency, concreteness, imageability and sensory experience rating. In 50% of the trials the words matched, and 50% of the words did not match. Of the non-match trials, 50% of the presented cues and targets did not rhyme or share similarities in spelling e.g., 'clock' and 'whale'. The rest of the non-match pairs were randomized to either orthographically rhyme (the rhyme is congruent with the spelling) e.g., 'clock' and 'sock'; non-orthographically rhyme (the rhyme is incongruent with the spelling) e.g., 'whale' and 'snail'; or words that were spelt similarly but did not rhyme e.g., 'match' and 'watch'.

Participants completed three blocks in counterbalanced order. Each block used the same stimulus type as a cue (spoken word, written word, or picture) and the remaining two stimulus types as targets. For example, a Written-Word block had randomly interspersed within it Written→Spoken and Written→Image verification trials. Both cues and targets were presented for 500ms. The ISI between trials was jittered between 800 and 1200ms in 100ms intervals. Each participant viewed 432 trial pairs (144 in each block).

Results

Cue-Target Verification

Accuracy was high (96%) and all analyses was conducted on correct RTs. Anticipatory responses <150ms were omitted. The data were analyzed in R using mixed effects models with subject, cue items and block items as random effects.

Figure 2 visualizes several basic findings from the cue-target verification study. First, there was a large effect of target-type: spoken-word targets required greater time to process than written words or picture-targets, t's > 15, p's < .0001. When cued by a spoken word, participants responded equally fast to picture and written targets.

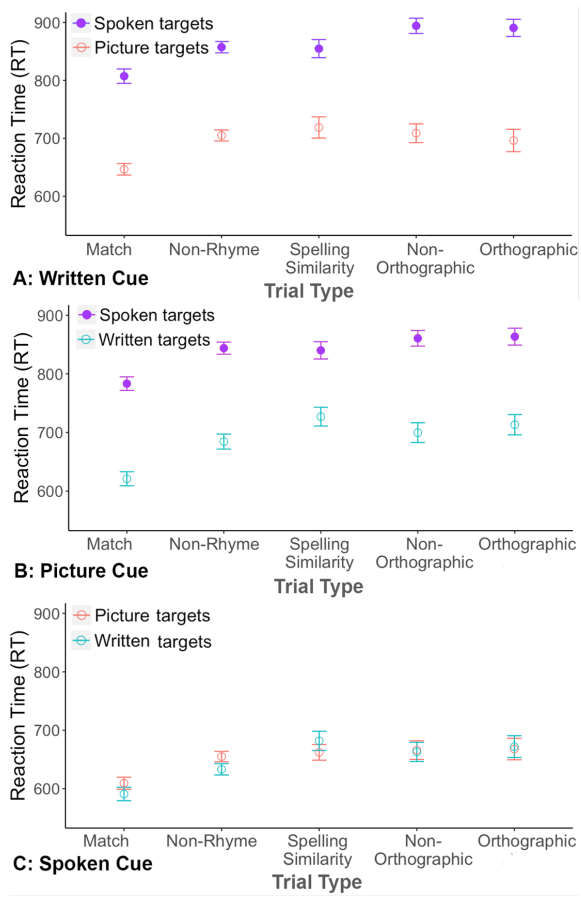

Figure 2. Correct RT across Trial Type and Target Type. Panels represent Cue types. Error bars signify 95% CI of the mean within subjects.

We then assessed the effect of trial type (non rhymes, orthographic rhymes, non-orthographic rhymes, and spelling similarity) on RTs. Responses were faster for match trials, (M=676 ms.) than for all other trials (t > 15, p < .0001). Non-rhyme trials (M=729 ms.) were faster than orthographic rhyme trials (M=747 ms.), non-orthographic rhyme trials (M=747 ms.), and spelling similarity trials M=746 ms., p's < 0.001. The delay in RT caused by orthographic rhymes was similar to non-orthographic trials does not differ significantly between each other, p > .05.

To better understand the rhyming effect, we collapsed the non-orthographic and orthographic rhymes and contrasted RTs for these *rhyming* trials, with RTs on *non-rhyme* trials using the following model:

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RT~is_rhyme+cue_type+target_type+(1+rhyme|subjCode)+(1|cue)
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Rhyme trials had significantly longer RTs, (b=18, t=5.88, p<.0001). Examining the interactions with cue-type and target-type revealed that rhyming did not interact with the cue-type t<1, but did interact with the target-type.

When the cue and target rhymed, RTs were increased significantly more for spoken-word targets (b=26, t=3.7, p=.0002) and written-word targets (b=14, t=2.06, p=.04), as compared to picture-targets. In fact, when the target was a picture, there was no significant effect of rhymes at all (b=4, t=.78, p=.44). That is, hearing or seeing the word "box" followed by the word "fox" (written or spoken) led to slower "not-a-match" responses compared to an unrelate target. However, hearing or seeing "fox" followed by a picture of a fox, did not slow down responses compared to unrelated picture targets.

We next examined how participants' IRQ responses related to their performance on the cue-target verification task. We began with an exploratory analysis examining how the scores on the four factors related to overall RT (Figure 3). Participants with a higher propensity to verbalize had longer RTs overall, (r=.23, p=.03). Visual examination revealed that individuals with a higher propensity to verbalize were particularly slowed when the cue was a picture (r=.29, p=.006) or written word (r=.22, p<.046). Propensity to verbalize did not predict RTs when the *cues* were spoken words (r=.14, p=.20), but remained positively correlated with RTs when the targets were spoken words, r=.26, p=.02). Other IRQ factors did not significantly predict overall RTs.

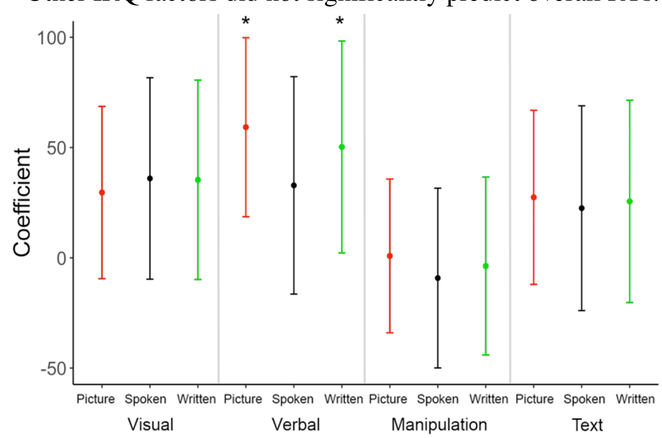

Figure 3. Regression coefficients for each factor in the IRQ, predicting correct RTs for the three cue types used in the verification task. Error bars signify 95% CI of the coefficients. Asterisks indicate significant differences from 0, p<.05.

We next examined whether the association between the propensity to verbalize and RTs depended on the relationship between the cue and target. If those with a higher propensity to verbalize are generating phonology from the cues to a greater extent, we might expect them to take especially long to respond to trials on which the cue and target rhymed. Hearing a spoken cue is likely to activate an auditory/verbal representation for all participants, regardless of their propensity for verbalization, and so the critical test involves examining the rhyme effect on trials containing a spoken cue or target compared to trials that only had written and pictorial cues/targets and relating this to propensity to verbalize, i.e., we are predicting a three-way interaction: spoken cue/target (is the cue or target spoken) x rhyme (do the cue and target rhyme?) x propensity to verbalize. The full model syntax (using centered predictors, including non-matching trials only) was:

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RT~isSpoken*verbal*rhyme+(1+isMatch+rhyme+isSpoken|subjCode)+(1|cue)
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The three-way interaction was reliable (b=41, t=2.98, p=.002), as was the two-way interaction between rhyming and propensity to verbalize (b=-24, t=2.62, p=.01). On trials containing a spoken cue or target, rhymes led to longer RTs (b=21, t=5.10, p<.0001) for people regardless of their propensity to verbalize (b=8.3, t=1.05, p=.29). On trials with only written-word or picture cues/targets, there was no overall rhyming effect (b=3.9, t=.73, p=.45), but the rhyming effect varied with the propensity to verbalize (b=-32, t=2.96, p=.003). *This latter effect is in the opposite direction of what was expected*. Participants with a *lower* propensity to verbalize were slowed down by rhymes while those with a higher propensity, were slightly *sped up by rhymes*. We comment on this unexpected finding below.

General Discussion

The study aimed to quantify individual variability in propensity to verbalize thought. The IRQ suggests that in addition to variability in propensity to visualize, people vary substantially in the degree to which they have a propensity to verbalize. The IRQ identified a novel orthographic imagery factor (i.e., frequent visualization of the written form of spoken words), a previously unreported type of imagery that warrants further investigation. The IRQ shows high internal validity and test-retest reliability.

As an initial test of the IRQ's external validity, we related participants profiles—focusing on the propensity to verbalize—to a cue-target verification task in which cues and targets were written words, spoken words, or pictures. Slower reaction times in the verification task were moderately associated with higher scores on the IRQ verbal factor. The slower responses may be related to activating phonology from written pictorial cues, or to activating a template representation against which a target is matched. Whatever the answer, judging by their longer overall RTs, individuals with a higher propensity to verbalize, were not obviously aided by this verbalization.

Consistent with our prediction the propensity to verbalize was most predictive on written-word and picture trials, consistent with the interpretation that individuals scoring high on the IRQ-verbal factor performed differently from low-scoring individuals specifically when the trial did not include an explicit phonological stimulus (i.e., written-word and picture trials).

As a way of investigating a particular correlate of the propensity to verbalize, we reasoned that participants who score high on this factor would tend to activate phonology of written words and pictures to a greater extent. This greater activation was predicted to show up as a larger rhyming effect (the slow-down in RTs when the cue and target rhymed). We found robust rhyming effects, particularly on trials containing a spoken cue or target. These rhyming effects did not interact with propensity to verbalize. On trials containing only written-words and pictures, we found no overall rhyming effect, consistent with the possibility that participants were not activating phonological representations to the same degree. We observed a strong interaction with the propensity to verbalize factor, but in the opposite direction of what was expected. Participants with the highest verbal factor scores actually showed a slightly *negative* rhyming effect, while participants scoring low on the factor showed a slightly positive effect. We hesitate to over-interpret this surprising result, but an intriguing possibility is that individuals with a higher propensity to verbalize may be activating phonological representations with greater precision (though at a cost of reduced RTs). When presented with a written word "box" followed by a picture of a fox, participants high on the verbal factor may activate its name with a high level of precision, while those with a lower propensity to verbalize may also activate its name, but in a more diffuse way, leading to a greater rhyming effect.

Conclusion

The present study represents an early exploration into the use a of the Internal Representation Questionnaire (IRQ), an instrument designed to assess people's reported propensity to visualize, verbalize (in a phonological form), and verbalize using orthographic imagery, in various contexts. An initial validation of the measure to predict performance in a speeded cue-target verification task suggests that people's self-reported propensities are tracking aspects of moment-to-moment cognitive processes. To further assess the external validity of the IRQ, it will be necessary to design tasks that relate to specific situations in which people report visualizing, verbalizing, and forming orthographic imagery, to different degrees.

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